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TECHNICAL MANUAL

SERVICE AND CIRCUIT DIAGRAMS
RADIO SET
AN/GRC-171

DEPARTMENTS OF THE ARMY, THE NAVY, AND THE AIR FORCE

1 MARCH 1975

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(Prefix each Reference Number with the Chapter Number denoted by the Column.)
(KEY: Numbers preceded by "f" are illustrations; "t" are tables; others are paragraphs.)

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					Org/Itmd	Adjustment
AUDIO MODULE A4	12	27, f3		12, 13, 14 20, 25, 27 135 thru 181, f7, fFO-7, fFO-21	28, t3, f8	14, 15, 16, 17
CHASSIS A10	18	26, f2		10, 27, 30, 31, 34, fFO-33	46, t3, f8	
D/A SERVO AMPLIFIER MODULE A1	9			1, 9, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, fFO-4, fFO-18	19, t3, f8	
DC-DC CONVERTER MODULE A5	13			32, 33, 34 182 thru 212, fFO-8, fFO-13, fFO-22	31, t3, f8, f9	
FREQUENCY SYNTHESIZER MODULE A2	10			15, 16, 41 60, 61 thru 97, t2, fl, f2. f3, f4, f5., f6, fFO-5. fFO-11, fFO-12, fFO-19	22, t3, f8	
KEYER MODULE A9	17	29, f4		14, 28, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, fFO-32	43, t3, f11	

CROSS-REFERENCE INDEX (Cont)

OFFICIAL NOMENCLATURE Common Name	Chapter 1 General Information	Chapter 2 Installation	Chapter 3 Operation	Chapter 4 Principles of Operation	Chapter 5	
					Org/Itmd	Adjustment
POWER AMPLIFIER MODULE A8	16			12, 15, 16, 18, 21, 241 thru 291, f9, fFO-10, fFO-25, fFO-26 thru fFO-31	40, t3, f8	
RADIO RECEIVER-TRANSMITTER RT-980/GRC-171 Receiver-Transmitter	fl, f2	4, 20, t1 IFO-1, fFO-2	1, 6, t1, f1	6, 7, 20, 36, fFO-3, fFO-15, fFO-15, fFO-16	8, t3, f1, f8	
RADIO SET CONTROL C-7999/ GRC-171 Radio Control	f1	5,. 22, t1 fl, fFO-2	8, t1, f2	6, 20, 27, 38, 39, 40, 41, fFO-17	8, t4	
RECEIVER RF MODULE A3	11	31, f5		7, 23, 24, 25, 98 thru 134. fFO-6, fFO-20	25, t3, f8	
RF FILTER MODULE A7	15			16, 23, 24, 26, 221 thru 240	37, t3, f8	
VOLTAGE REGULATOR MODULE A6	14			32, 213 thru 220, f8, fFO-23	34, t3, f8, f10	

INTRODUCTION

This technical manual provides information for servicing Radio Set AN/GRC-171, Collins part number 622-1627-001, manufactured by Collins Radio Group/ Rockwell International, Cedar Rapids, Iowa. Radio Set AN/GRC-171 consists of the following: Radio Receiver-Transmitter RT-980/GRC-171, Collins part number 622-1628-001; Radio Set Control C-7999/ GRC-171, Collins part number 622-1629-001; cable interface kit, Collins part number 622-7846-001; and slide mounting hardware kit, Collins part number 623-5818-001. Radio Set AN/GRC-171 provides air traffic control communications at collocated vhf/uhf receiver-transmitter sites. The equipment is capable of providing AM communications on any of the 7,000 channels in the 225to 399.975-MHz band with 20watt AM carrier output.

Chapter 1 provides an overall electrical and mechanical description of the equipment.

Chapter 2 provides information on installation, of the equipment.

Chapter 3 provides operating instructions.

Chapter 4 describes the basic operating principles of the equipment.

Chapter 5 provides maintenance instructions, including performance tests and adjustment procedures.

Chapter 6 provides information on the use of circuit diagrams and equipment effectivity. All foldout diagrams appear in chapter 6 of this manual regardless of their applicability to any one chapter.

A complete illustrated parts breakdown of the equipment is provided in TO 31R2-2GRC171-4.

The following publications were used in the preparation of this manual.

MILITARY STANDARDS

MIL-STD-12B Abbreviations for Use on Drawings and in Technical-Type manuals

VIIL-STD-15-1A Graphic Symbols for Electrical and Electronic Diagrams

ASA-STD-Y32-16-1965 Electrical and Electronic Reference Designations

MILITARY SPECIFICATIONS

MIL-M-38730 Technical Manuals, General Requirements for Preparation of

MIL-M-4410 Technical Manuals: Title Pages, List of Effective Pages, and Reproduction Assembly Sheet; Photolith Negatives; Printing; and Binders

MIL-T-9941 Technical Manuals: Ground C-E Equipment Facility, Site, and System

TECHNICAL ORDERS

31-1-141 Basic Electronics Technology and Testing Practices

EFFECTIVITY

Each equipment, unit, and assembly provided is marked with a manufacturing alphabetic identifier in addition to the basic part number. The alphabetic identifier will be preceded by the letters REV(revision) and will start with 0 if no changes have been processed. The first change will be identified as A, the second as B, and continuing through Z to AA and ultimately to ZZ. Because minor electrical and/or mechanical differences exist between various revisions, where applicable, an effectivity-versus-revision identifier cross-reference is provided on the schematic diagram.

Each effectivity applies to a group of revision identifiers and is indicated by a key (🡐) on both the effectivity table and the appropriate schematic diagram.

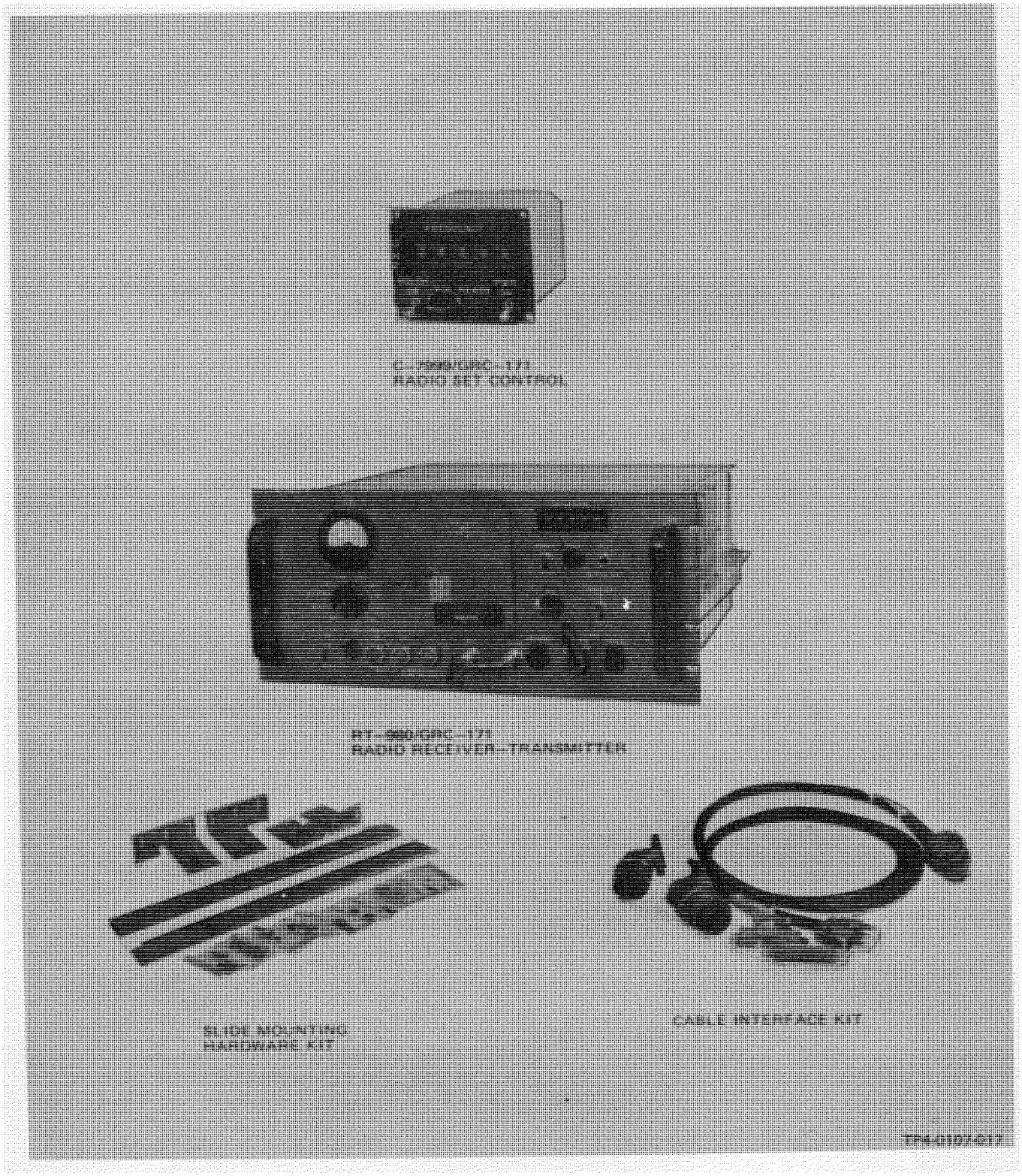


Figure 1-1. Radio Set AN/GRC-171 1-0

CHAPTER 1
GENERAL INFORMATION

1-1. DESCRIPTION AND PURPOSE.

1-2. PURPOSE. Radio Set AN/GRC-171, shown in figure 1-1, is a uhf receiver-transmitter for air traffic control communications at collocated vhf/uhf receiver-transmitter sites. The equipment provides AM and wide-band data communications on any 1 of 7000 channels (25-kHz channel spacing) in the 225to 399.975-MHz band. The equipment is completely solid state providing 20-watt AM carrier output.

1-3. DESCRIPTION. Radio Set AN/GRC-171 (radio set) consists of Radio Receiver-Transmitter RT980/GRC-171 (receiver-transmitter), Radio Set Control C-7999/GRC-171 (radio control), a cable interface kit, and a slide mounting hardware kit.

1-4. The RT-980/GRC-171 consists of nine plug-in modules (shown in figure 1-2) contained within a chassis. The modules are attached to the chassis by captive screws or by a module retaining bracket. All electrical connections to the RT-980/GRC-171 are made through four connectors mounted on the rear panel of the chassis. Front panel test meter and test points are provided for maintenance and troubleshooting. The unit mounts in a standard 482.6-mm (19-in) rack cabinet and is cooled by convection. The RT-980/GRC-171 can be operated locally with front panel controls or remotely at distances up to 45.7 m (150 ft) with Radio Set Control C-7999/GRC-171.

1-5. The cable interface kit contains a 1.83-m (6-ft) 120-V ac power cord and all multiple pin mating connectors for the RT-980/GRC-171 and C-7999/ GRC-171. All interconnecting wiring except the 120-V ac power cord is supplied by the user.

1-6. The slide mounting hardware kit contains the cabinet slides, brackets, and hardware required to mount the RT-80/GRC-171 in a standard 482.6-mm (19-in) rack cabinet. Slide rails are attached to the RT-980/GRC-171 at the factory.

1-7. Radio Set Control C-7999/GRC-171 contains controls for remote frequency select, power on-off, squelch on-off, and receive audio level control.

1-8. DESCRIPTION OF MODULES.

1-9. D/A SERVO AMPLIFIER MODULE Al. The d/a servo amplifier contains a digital-to-analog converter and servo amplifier that converts frequency select information from the radio control into servo motor drive to position the rf filter in the rf filter module.

1-10. FREQUENCY SYNTHESIZER MODULE A2. The frequency synthesizer module contains a phaselocked loop (p11) and transmit/receive transfer switch that converts frequency select information from the radio control into transmit rf that is transferred to the power amplifier module or receive injection that is transferred to the receiver rf module.

1-11. RECEIVER RF MODULE A3. The receiver rf module contains a double conversion uhf receiver that converts receive rf from the rf filter module into receive audio (or data) to the audio module. The receiver rf module includes a noise channel to blank receive audio of impulse type noise.

1-12. AUDIO MODULE A4. The audio module contains a receive audio circuit with squelch, a transmit audio circuit, and a transmitter keying circuit. The audio circuit amplifies and shapes the frequency response of receive audio (or data) from the receiver rf module and applies the audio (or data) to the headset and main audio output (or data output) of the receiver-transmitter. The transmit audio circuit amplifies and shapes the frequency response of input audio (or data) and applies transmit audio (or data) to the modulator of the power amplifier module. The transmit keying circuit converts remote push-to-talk keying into transmit key lines.

1-13. DC-DC CONVERTER MODULE A5. The dc-dc converter module contains a regulating dc-dc converter and a nonregulating dc-dc converter. The regulating dc-dc converter converts unregulated dc from the transformer/rectifier circuit on the chassis into regulated +26 V dc. The nonregulating dc-dc converter converts +26 V dc into unregulated voltages to the voltage regulator module.

1-14. VOLTAGE REGULATOR MODULE A6. The voltage regulator module converts unregulated voltages to power circuits of the receiver-transmitter and radio control.

1-15. RF FILTER MODULE A7. The rf filter module contains a transmit/receive switch, tunable rf filter, and directional coupler that transfers and filters transmit rf from the power amplifier module to the antenna or receive rf from the antenna to the receiver rf module.

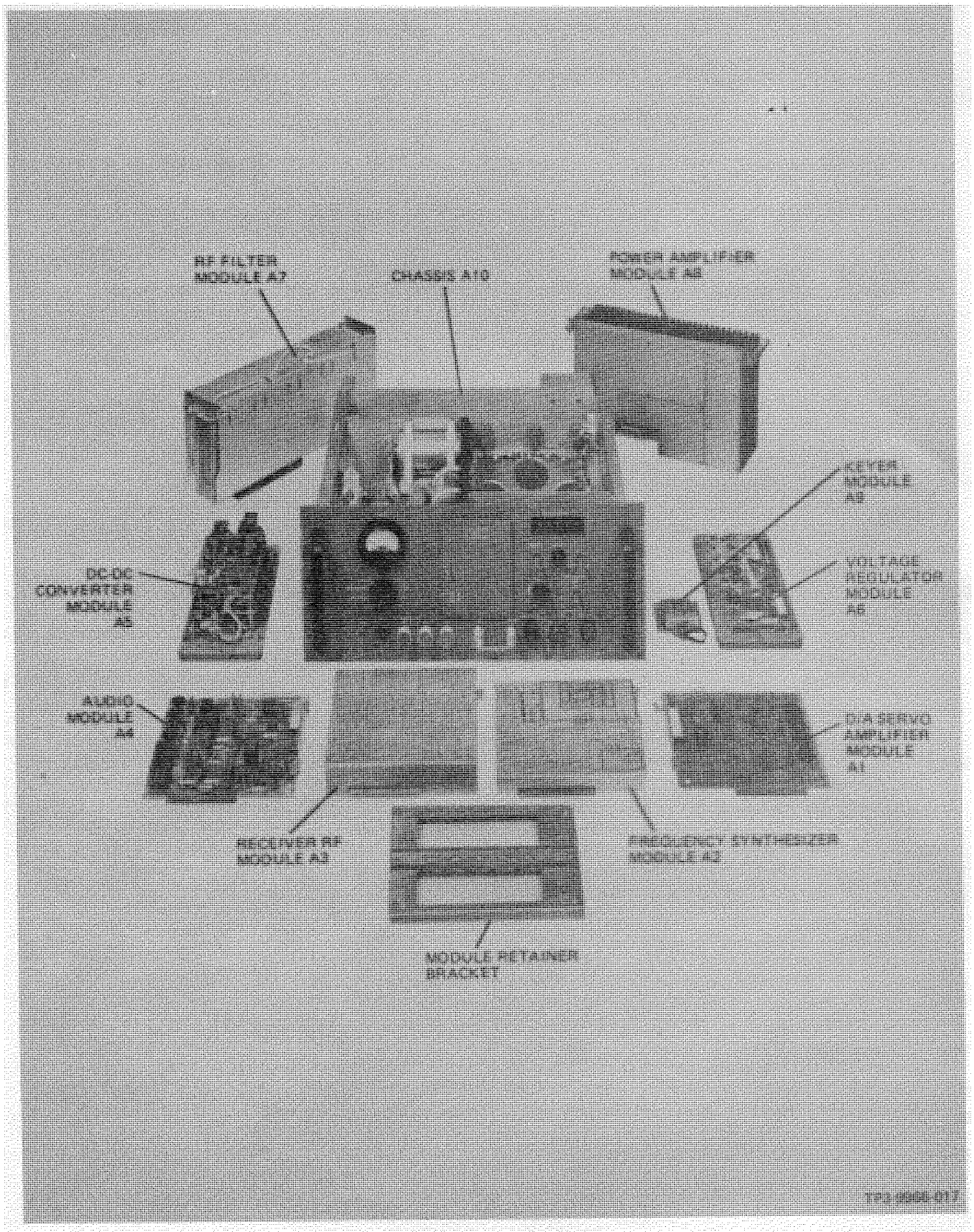


Figure 1-2. Radio Receiver-Transmitter RT-980/GRC-171, Module Identification

1-16. POWER AMPLIFIER MODULE A8. The power amplifier module contains a modulator circuit and rf driver and power amplifier circuits with automatic load control. The power amplifier amplitude modulates transmit rf from the synthesizer module with transmit audio from the audio module to provide transmit rf to the rf filter module.

1-17. KEYER MODULE A9. The keyer module contains a keyer circuit that converts remote voltage, current, or audio loop keying into remote keying to the transmit keying circuit of the audio module. In addition, the keyer module contains a squelch operated relay circuit.

1-18. CHASSIS AND FRONT PANEL A10. The chassis contains all connectors, wires, and coaxial cables necessary to interconnect the nine modules of the receiver-transmitter. In addition, the chassis contains an emi filter that filters all wires that enter or leave the receiver-transmitter. The chassis contains power supply components that convert input ac power into unregulated dc voltage to the dc-dc converter module.

1-19. The chassis front panel contains the power on-off switch, power supply fuses, a meter circuit and test points, level controls for receive audio, sidetone, squelch, modulation, and headset volume along with jacks for a headset and microphone. In addition, the chassis front panel contains a local-remote switch and all the controls necessary for local frequency select, transmitter keying, and squelch on-off.

1-20. LEADING PARTICULARS.

1-21. Table 1-1 lists the leading particulars of Radio Set AN/GRC-171.

1-22. CAPABILITIES AND LIMITATIONS.

1-23. Table 1-2 lists the capabilities and limitations of Radio Set AN/GRC-171.

1-24. EQUIPMENT SUPPLIED.

1-25. Table 1-3 provides a list of equipment supplied, together with dimensions and weight.

1-26. EQUIPMENT REQUIRED BUT NOT SUPPLIED.

1-27. Table 1-4 lists the test equipment required to maintain Radio Set AN/GRC-171. Equivalent test equipment may be used. Refer to table 5-1 for test equipment test characteristics.

Table 1-1. Leading Particulars (Sheet 1 of 2)

ITEM	DESCRIPTION
Power source Primary power	95 to 132 V ac; 189 to 264 V ac; 47 to 63 Hz; 380 to 420 Hz; single-phase. NOTE Primary power strapping is provided for ac line voltages of 105, 120, 210, and 240 V ac +10%. The AN/GRC-171 is shipped strapped for 120 V ac.
Emergency power	24-V dc battery. NOTE A 24-V dc battery bus may be floated across the dc input to the RT-980/GRC-171 to provide emergency power in the event of an ac power failure. The switch over to battery power is automatic.
Alternate power	22 to 30 V dc. NOTE In place of ac power, the AN/GRC-171 may be operated from a dc power source of 22 to 30 V dc. The AN/GRC-171 is capable of rated performance while being operated on dc power.

Table 1-1. Leading Particulars (Sheet 2 of 2)

ITEM	DESCRIPTION
Power input	450 watts transmit, 150 watts receive.
Ambient temperature	
Operating	-29 °C (-20 °F) to 60 °C (140 'F).
Nonoperating/storage	-62 °C (-80 'F) to 71 °C (160 °F).
Altitude	-0 to 3048 m (10,000 ft) ms1.
Relative humidity	5 to 95%.
Weight	
RT-980/GRC-171	33.8 kg (74.5 lb).
C-7999/GRC-171	0.31 kg (0.69 lb).
Overall dimensions	
RT-980/GRC-171 (including slide rails)	222.3 mm (8.75 in) high, 482.6 mm (19 in) wide, and 533.4 mm (21 in) deep.
C-7999/GRC-171	66.7 mm (2.62 in) high, 82.6 mm (3.25 in) wide, and 114.3 mm (4.5 in) deep.
Mounting	
RT-980/GRC-171	Standard 482.6-mm (19-in) rack with slide mounting.
C-7999/GRC-171	Panel mounting.
Ventilation	Convection cooling.
Cabling requirements	Maximum cable length between RT-980/GRC-171 and C-7999/GRC-171 is 45.7 m (150 ft) when interconnect cabling consists of unshielded #22 AWG wire. Cable length can be extended from 45.7 m (150 ft) to a maximum of 305 m (1000 ft) if the requirements of figure FO-2, chapter 6, are met.

Table 1-2. Capabilities and Limitations (Sheet 1 of 6)

CHARACTERISTIC	SPECIFICATION
GENERAL	
Frequency range	225.000 to 399.975 MHz.
Number of channels	7000.

Table 1-2. Capabilities and Limitations (Sheet 2 of 6)

<table>
<tr><th>CHARACTERISTIC</th><th>SPECIFICATION</th></tr>
<tr><td colspan="2">GENERAL (Cont)</td></tr>
<tr><td>Channel spacing</td><td>25 kHz.

NOTE

The radio set is capable of tuning to 1 of 7000 frequency channels spaced at 25-kHz intervals. However, the receiver selectivity is determined by the crystal filter (A4FL1) installed in the 10.7-MHz if circuit of receiver rf module A3. The bandwidth of the filter supplied with the radio set is 36 kHz (6-dB resonant response). This makes the radio set compatible with 50-kHz channel spacing. To make the radio set compatible with 25-kHz channel spacing, the filter must be replaced with a 20-kHz bandwidth filter. To allow reception of wide bandwidth data, the filter must be replaced with a 60-kHz bandwidth filter (100-kHz channel spacing).</td></tr>
<tr><td></td><td>0.0005% both transmit and receive.</td></tr>
<tr><td>Frequency stability</td><td>±0.0005% both transmit and receive.</td></tr>
<tr><td>Frequency accuracy</td><td>seconds maximum after selection of last digit.</td></tr>
<tr><td>Tuning time 10</td><td>2 minutes.</td></tr>
<tr><td>Warm-up time</td><td></td></tr>
<tr><td>Duty cycle</td><td>90% with 9 minutes (90%, 1-kHz modulation) transmit and 1 minute receive.</td></tr>
<tr><td>Transmitter</td><td>Continuous.</td></tr>
<tr><td>Receiver</td><td>50-ohm, N-type connector.</td></tr>
<tr><td>Antenna input</td><td></td></tr>
<tr><td colspan="2">RECEIVER</td></tr>
<tr><td>Sensitivity</td><td>3 microvolts (30% modulation, 1000 Hz) applied at the antenna will produce an audio output of 100 milliwatts into 600 ohms with a 10-dB (minimum) signal-plus-noise to noise ratio.</td></tr>
<tr><td>Selectivity</td><td>Receiver selectivity is determined by the crystal filter (A4FL1) installed in the 10.7-MHz if amplifier. Refer to note in general specifications of this table.

RESONANT RESPONSE (dB) — TOTAL BANDWIDTH (kHz)
Narrow bandwidth 36-kHz filter (50-kHz channel spacing): 6 — 36; 20 — 54; 40 — 62; 60 — 70; 80 — 80</td></tr>
</table>

Table 1-2. Capabilities and Limitations (Sheet 3 of 6)

CHARACTERISTIC	SPECIFICATION
RECEIVER (Cont)	
	RESONANT RESPONSE (dB) / TOTAL BANDWIDTH (kHz)
Narrow bandwidth 20-kHz filter (25-kHz channel spacing)	6 / 20 20 / 28 40 / 30 60 / 32 80 / 40
Wide bandwidth 60-kHz filter (100-kHz channel spacing)	6 / 60 60 / 104 80 / 120
Audio outputs	
Narrow bandwidth audio	Two transformer output circuits simultaneously deliver the following power output levels when receiving a 3-microvolt, 30% modulated (1000-Hz tone) signal. Main audio: At least 100 milliwatts into a 600-ohm external resistive load; adjustable by a recessed (screwdriver adjustable) control located on the front panel of the RT-980/GRC-171. Headset audio: At least 100 milliwatts into a 600-ohm external resistive load; controllable by a volume control located on the front panel of the RT-980/GRC-171.
Wide bandwidth audio	Secure/data audio: At least 0.5 volt across a 10,000-ohm resistive load when receiving a 3-microvolt, 30% modulated (1000-Hz tone) signal.
Audio bandpass	SIGNAL (Hz) / REFERENCE LEVEL CHANGE (dB)
Main/headset audio	100 / -10 300 / +1, -2 1,000 (ref) / 0 3,000 / +1, -2 10,000 / -10
Secure/data audio	16 / +1, -3 1,000 (ref) / 0 25,000 / +1, -3
Audio distortion	10% or less when receiving a 1-volt input signal modulated 30% (300, 1500, and 3000 Hz) and with the audio level adjusted to an output of 100 milliwatts into 600-ohm load. 15% or less for the same rf input modulated at 90%.
Audio level control	3-dB or less increase in audio output level (100-milliwatt output reference for 30% modulation) as modulation increases from 30 to 907% (10-microvolt rf input).

Table 1-2. Capabilities and Limitations (Sheet 4 of 6)

CHARACTERISTIC	SPECIFICATION
RECEIVER (Cont)	
Audio level regulation	4-dB or less decrease in audio output voltage level (100-milliwatt output reference for 600-ohm load resistor) for a 5-to-1 reduction (120 ohms) in load resistor.
Automatic gain control (AGC)	3-dB or less change in audio output level (100-milliwatt output reference for 6-microvolt input signal, modulated 30%) as the input signal increases from 6 microvolts to 1 volt.
AGC time constant	100-millisecond attack time, 500-millisecond release time.
Squelch	A carrier-operated noise silencer mutes the receiver output pending application of carrier inputs not greater than 3 microvolts with squelch sensitivity at maximum setting and not less than 50 microvolts with squelch sensitivity at minimum setting.
Carrier-operated relay	A spdt relay operates in synchronism with the squelch circuit for use with external devices.
Noise blanker	A noise blanker circuit reduces the presence of impulse noise at the receiver audio output when rf pulses with the following characteristics are introduced into the receiver input.

PULSE WIDTH	PULSE REPETITION FREQUENCY	PULSE SHAPE
10 ±2 μs	360 ±60 prf	Rise and decay time less than 1 μs
2 ±1 μs	900 ±600 prf	Rise and decay time less than 0.1 μs

NOTE

Noise blanker can be disabled by a noise blanker strapping option on receiver rf module A3, or by grounding the external noise blanker disable line of rear panel connector J22 pin j, or by installing the wide bandwidth filter (A4FL1) which has a special noise blanker disable pin.

Hum and noise	Not less than 50 dB below the rated audio output level of 100 milliwatts.
TRANSMITTER	
Power output	20 watts into a 50-ohm resistive load throughout the frequency range 225 to 399.975 MHz.

NOTE

The transmitter power output will automatically reduce to approxi mately 4 watts if the pa heat-sink temperature exceeds 100 °C, or if the antenna vswr exceeds 3.1, or if the rf filter insertion loss increases above approximately 2 dB.

Table 1-2. Capabilities and Limitations (Sheet 5 of 6)

CHARACTERISTIC	SPECIFICATION
TRANSMITTER (Cont)	
Output impedance	50 ohms.
Output vswr	1.3:1 or less normal; 3:1 maximum.
Automatic load control (ALC)	ALC maintains the carrier power level between -1 and +1 dB of the rated power output level at all operating frequencies under normal operating conditions when operating into load vswr of 3:1 or less.
Modulation	Amplitude modulation to the level of 90% from the following modulation inputs.
Modulation inputs	Main audio:. -15 to +10 dB mW (-35 to -15 dB mW optional), 600/150 ohms, balanced, ungrounded.
Secure/data audio:	0 dB mW, 600 ohms, unbalanced, grounded.
Microphone:	Dynamic and carbon microphone, low impedance.
Modulation limiting and compression	Automatically limited to 90% maximum and maintained at 80 to 90% for above modulation inputs; will not overmodulate for inputs above +10 dB mW.
Modulation response	SIGNAL (Hz) / REFERENCE LEVEL CHANGE (dB)
Main audio	100: -10 or greater 300: +1, -2 1,000 (ref): 0 6,000: +1, -2 10,000: -10 or greater
Secure/data audio	16: +1, -3 1,000 (ref): 0 25,000: +1, -3
Modulation distortion	10% or less under conditions of 0-dB mW compression; 15% or less under conditions of maximum compression and limiting.
Sidetone	Detected rf applied to receiver main/headset audio circuits provides at least 100 milliwatts across 600 ohms when transmitter is modulated 90% with a 1000-Hz tone; level adjustable by a recessed (screwdriver adjustable) control located on the front panel of the RT-980/GRC-171.
Carrier hum and noise	Not less than 50 dB below a 1000-Hz test tone with transmitter operating at 20-watt carrier power, 90% modulated.
Harmonic and spurious output	At least 80 dB below level of carrier fundamental.

Table 1-2. Capabilities and Limitations (Sheet 6 of 6)

CHARACTERISTIC	SPECIFICATION
TRANSMITTER (Cont)	
Keying	
Main audio center tap keying	Ground (optional 6, 26, or 48 volts) keying. For ground keying, key line keying provides 22-volt keying potential.
Remote ptt keying	Ground keying.
Local ptt keying	Ground keying through carbon or dynamic microphone ptt switch or front panel PTT/CARRIER TEST switch.
Loop keying	Voltage: 6 volts (optional 26, 48, or 100 volts) with loop impedance of 47 kilohms. Current: 20 or 60 milliamperes with loop impedance of 150 ohms. Audio: 0.245 V rms audio tone, 300 to 3000 Hz, 600 ohms (optional VOX keying).

Table 1-3. Equipment Supplied (Sheet 1 of 3)

QTY	NOMENCLATURE	COLLINS PART NUMBER	DIMENSIONS mm (in)			WEIGHT kg (lb)
			LENGTH	WIDTH	HEIGHT	
1	Radio Receiver-Transmitter, RT-980/GRC-171 consisting of the following:	622-1628-001	487.7 (19.20)	482.6 (19.00)	221.5 (8.72)	33.8 (74.5)
1	D/a servo amplifier module A1	621-6607-001				
1	Frequency synthesizer module A2	621-7956-001				
1	Receiver rf module A3	621-7957-001				
1	Audio module A4	621-6606-003				
1	Dc-dc converter module A5	621-7959-001				
1	Voltage regulator module A6	621-7958-001				
1	Rf filter module A7	621-7960-001				

Table 1-3. Equipment Supplied (Sheet 2 of 3)

QTY	NOMENCLATURE	COLLINS PART NUMBER	DIMENSIONS mm (in)			WEIGHT kg (lb)
			LENGTH	WIDTH	HEIGHT	
1	Power amplifier module A8	621-7955-001				
1	Keyer module A9	621-7961-001				
1	Receiver-transmitter chassis A10	621-7975-001				
1	Coaxial jumper (part of receiver-transmitter chassis A10)	357-8992-010				
1	Radio Set Control C-7999/GRC-171	622-1629-001	114.3 (4.50)	82.6 (3.25)	66.7 (2.62)	0.31 (0.69)
1	Cable interface kit consisting of the following:	621-7846-001	355.6 (14)	355.6 (14)	50.8 (2)	0.74 (1.63)
2	Lockscrew assembly	371-0040-000				
1	Hood	371-0187-000				
1	Remote control cable connector	371-0358-240				
1	Remote control cable connector	371-6271-000				
1	Audio connector	361-6523-000				
1	Electrical power cable	623-5949-001				
1	Slide mounting hardware kit consisting of the following:	623-5818-001	711.2 (28)	177.8 (7)	101.5 (4)	3.4 (7.5)
1	Left cabinet slide	015-3622-010				
1	Right cabinet slide	015-3622-020				
4	Flat washer	310-0048-000				
10	Flat washer	310-0050-000				
8	Lockwasher	310-0072-000				
10	Lockwasher	310-0286-000				
2	Lockwasher	310-0288-000				

Table 1-3. Equipment Supplied (Sheet 3 of 3)

QTY	NOMENCLATURE	COLLINS PART NUMBER	DIMENSIONS mm (in)			WEIGHT kg (lb)
			LENGTH	WIDTH	HEIGHT	
8	Nut	313-0017-000				
2	Nut	313-0082-000				
8	Screw	342-1350-350				
10	Screw	343-1540-000				
2	Guide	623-5735-001				
1	Front left slide bracket	623-5813-001				
1	Front right slide bracket	623-5813-002				
1	Rear left slide bracket	623-5814-001				
1	Rear right slide bracket	623-5814-002				

Table 1-4. Equipment Required But Not Supplied (Sheet 1 of 6)

OFFICIAL NOMEN	COMMON NAME	PART NO OR MFR MODEL NO	PURPOSE AND DESCRIPTION	MAINT LEVEL,
AN/USM-323	Rf generator/ frequency counter	HP 8640B	Provides rf input signal for testing. Dc to 500 MHz, checks frequency during operational checks. Quantity two required. Provides rf signal for noise blanking test and modulation percentage.	O, I, D
	Rf voltmeter	Boonton 91DA	Provides millivolt measurement in the rf range.	O, I, D
	Audio oscillator	HP 200CD	Provides audio input for testing.	O, I, D
	Distortion analyzer	HP 333A	Measures audio output level and percent output distortion for testing.	O, I, D
	Wattmeter	Bird 43	Measures rf forward power output and reflected power.	O, I, D

Table 1-4. Equipment Required But Not Supplied (Sheet 2 of 6)

OFFICIAL NOMEN	COMMON NAME	PART NO OR MFR MODEL NO	PURPOSE AND DESCRIPTION	MAINT LEVEL
	Plug-in element	Bird 50D	With wattmeter, measures rf forward power output and reflected power.	O, I, D
	Variable attenuator	General Radio 874-GAL	Provides sample of rf output.	O, I, D
	Rf load	Bird 8130	50 ohms nonreactive, 30 watts; used for testing.	O, I, D
	Decade resistance box	General Radio1432N	0 to 200 ohms in 1-ohm steps; provides test select resistor for testing	D
	Vom	Simpson 260	Continuity, general voltage and resistance checks.	O. I, D
	Attenuator	Measurements Corp 80 ZH3	Provides a constant impedance to the rf generator during testing.	O, I, D
	Pulse generator	Data Pulse 101	Provides pulse modulation for rf signal generator for noise blanking test.	I, D
	Power divider	Weinschel 1506N	Provides method of combining two rf signals for noise blanking test.	I, D
	Power supply	HP 6268B	Provides primary power for dc-dc converter module testing.	D
MIL-0-9960C	Oscilloscope		Provides display of modulation envelope and waveforms for fault isolation.	O, I, D
H-169U	Handset		Provides method to operate the RT-980/GRC-171 in the local mode.	O, I, D
	Digital multimeter	Fluke 8000A-01	Provides voltage measurements for testing.	O, I, D
	Double balanced mixer	HP 10514A	Provides test signal to oscillo-scope for percent modulation check.	O, I, D
	Cable assemblies kit	CPN 622-1802-001	Provides five extender cables and five coaxial cables required to perform limited module repair.	I

Table 1-4. Equipment Required But Not Supplied (Sheet 3 of 6)

OFFICIAL NOMEN	COMMON NAME	PART NO OR MFR MODEL NO	PURPOSE AND DESCRIPTION	MAINT LEVEL
	Audio test fixture	Locally fabricated (Refer to figure FO-34.)	Provides access to remote audio and keying functions for the purpose of interconnecting test equipment to test remote operation.	O, I
	Power supply	HP 6299A with option 09	Provides voltages and current source to check keyer module for proper operation.	O, I
	Rf filter test set	CPN 622-1795-001	Provides a method of: a. Interconnecting test devices to the module being tested. b. Measuring outputs of the module being tested. c. Supplying motor voltage and feedback information to the module being tested. d. Selecting various operating frequencies. e. Simulating a key line. Provides supply voltages for the module being tested for performing module testing and repair. Test set includes two tracking covers, one reference plate, and one centering tool.	D
	D/a servo amplifier test set	CPN 622-1796-001	Provides a method of; a. Measuring key interlock, alternate key interlock, servo motor, and position feedback voltages. b. Simulating bcd channel information, synthesizer lock input, bit key enable, and feedback information from the rf filter. Provides supply voltages for the module being tested for performing module testing and repair.	D

Table 1-4. Equipment Required But Not Supplied (Sheet 4 of 6)

OFFICIAL NOMEN	COMMON NAME	PART NO OR MFR MODEL NO	PURPOSE AND DESCRIPTION	MAINT LEVEL
	Frequency synthesizer test set	CPN 622-1797-001	Provides a method of: a. Interconnecting test devices to the module being tested. b. Obtaining frequency output of the module being tested. c. Simulating receive-transmit control functions. d. Displaying lock-monitor output. Provides supply voltages for the module being tested for performing module testing and repair.	D
	Receiver rf test set	CPN 622-1798-001	Provides a method of: a. Interconnecting test devices to the module being tested. b. Measuring 10.7-MHz if output, audio output, AGC sample, and the rf attenuator output. c. Producing 30-MHz if output. Provides supply voltages for the module being tested for performing module testing and repair.	D
	Audio module test set (Cont)	CPN 622-1799-001	Provides a method of: a. Interconnecting test devices to the module being tested. b. Simulating AGC input, squelch input, modulation gain control, squelch on-off, ptt and key lines, p11 fault logic level, and rf filter fault logic level. c. Monitoring transmit audio, receive audio, and ready condition.	D

Table 1-4. Equipment Required But Not Supplied (Sheet 5 of 6)

OFFICIAL NOMEN	COMMON NAME	PART NO OR MFR MODEL NO	PURPOSE AND DESCRIPTION	MAINT LEVEL
	Audio module test set (Cont)		Provides supply voltages for the module being tested for performing module testing and repair.	
	Voltage regulator	CPN 622-1800-001	Provides a method of: test set a. Interconnecting test devices to the module being tested. b. Evaluating regulator operation. c. Measuring output voltages and their ripple content. Provides supply voltages for the module being tested for performing module testing and repair.	D
	Power amplifier test set	CPN 622-1801-001	Provides a method of: a. Interconnecting test devices to the module being tested. b. Measuring modulation percentage. c. Performing hum, noise, and distortion tests. d. Simulating forward and reflected power analog inputs. Provides supply voltages for the module being tested for performing module testing and repair.	D
	Dc-dc converter test set	CPN 622-1812-001	Provides a method of: a. Interconnecting test devices to the module being tested. b. Measuring output voltages and their ripple content. c. Simulating operational loads. Provides supply voltages for the module being tested for performing module testing and repair.	D

Table 1-4. Equipment Required But Not Supplied (Sheet 6 of 6)

OFFICIAL NOMEN	COMMON NAME	PART NO OR MFR MODEL NO	PURPOSE AND DESCRIPTION	MAINT LEVEL
AN/USM-216	Digital multimeter		Provides method of measuring the d/a servo amplifier module digital-to-analog converter circuit voltages with an accuracy exceeding ±0.025%.	D
	Power oscillator	AILTECH 445	Provides an adjustable rf power source for testing and alignment of the rf filter module.	D
	Uhf plug-in head	AILTECH 186	Provides means to operate the power oscillator AILTECH 445 in the uhf range with power output up to 35 watts.	D
	50-ohm coupling capacitor	General Radio 874K	Provides means of coupling signal and blocking dc voltage during rf filter receiver attenuation test.	D
Maintenance level abbreviations:		O - organization I - intermediate D - depot		

CHAPTER 2
INSTALLATION

INTRODUCTION

This chapter provides the information necessary for the installation of Radio Set AN/GRC-171. Section I, installation planning, briefly describes installation considerations. Section II contains logistic data pertaining to receiving and unpacking the equipment, and section III provides instructions for installing and checking the equipment. Instructions for reshipment of the equipment are provided in section IV.

SECTION I
INSTALLATION PLANNING

2-1. GENERAL.

2-2. There are no special instructions required for installation planning. A discussion of mounting and cabling follows.

2-3. MOUNTING.

2-4. Radio Receiver-Transmitter RT-980/GRC-171 mounts on slides in a standard482.6-mm (19-in) rack. The unit requires 222.3 mm (8.75 in) of vertical clearance and 546.1 mm (21.50 in) of front-to-rear clearance. Rack slides are included in the slide mounting hardware kit.

2-5. Radio Set Control C-7999/GRC-171 requires a 82.6-mm (3.25-in) by 66.7-mm (2.62-in) mounting space for the front panel with approximately 152.4-mm (6.00-in) front-to-rear clearance to allow for the unit and the mating connector. The unit is mounted with four screws, one in each corner of the front panel.

2-6. CABLING.

2-7. A cable interface kit is supplied with Radio Set AN/GRC-171. The kit contains mating multiple pin connectors for the receiver-transmitter and the control units. The interconnecting wiring is supplied by the user. The maximum wire length between RT-980/GRC-171 and C-7999/GRC-171 is 305 m (1000 ft). Refer to figure FO-2, chapter 6.

SECTION II.
LOGISTICS

2-8. RECEIVING DATA.

2-9. The equipment is supplied in three shipping cases. Table 2-1 lists the items contained within each case.

2-10. MATERIAL HANDLING.

2-11. The shipping cases and contents weigh approximately 56.02 kg (123.5 lb) and may be carried by 2 men.

2-12. UNPACKING.

2-13. Use standard unpacking procedures to remove the equipment from the shipping case. When unpacking, be careful not to damage the equipment.
Inspect all components for damage, such as dents, marred finishes, etc. Check that all components of the RT-980/GRC-171 and the C-7999/GRC-171 are securely fastened in place. Check the equipment against the packing slip and table 2-1 to be sure that all components have been received. Report any damage or missing components to the proper personnel.
Save all packing material.

2-14. CABLE REQUIREMENTS.

2-15. A cable interface kit is supplied with Radio Set AN/GRC-171. The interface kit contains the mating connectors required to provide all electrical connections to the RT-980/GRC-171 and the C-7999/GRC171. All interconnecting wiring, except the 1.83-m (6-ft) 120-V ac power cord, is supplied by the user.
The 120-V ac power cord is factory prewired to the mating connector for the primary power jack.

2-16. An installation wiring diagram for the radio set is shown in figure FO-2. The diagram shows all the wiring necessary for installation in the user facility. The interconnecting wiring should be in place and mating connectors installed before the units are installed. Provide enough slack in cables to allow the RT-980/GRC-171 to be pulled fully forward on the slides. Observe the following precautions when installing the interconnecting wiring.

a. For minimum pickup of electrostatic and magnetic interference on audio and microphone lines, use shielded twisted pair, with one end grounded. Standard twisted telephone cable pairs may be used for remote operation.

Table 2-1. Receiving Data

ITEM	*DIMENSIONS mm (in)			*WEIGHT kg (lb)
	LENGTH	WIDTH	HEIGHT	
Radio Receiver-Transmitter RT-980/GRC-171, CPN 622-1628-001	838.2 (33)	736.6 (29)	508 (20)	44.23 (97.5)
Radio Set Control C-7999/GRC-171, CPN 622-1629-001	203 (8)	177.8 (7)	127 (5)	1.81 (4)
Cable/hardware kit containing the following: Cable interface kit, CPN 622-7846-001 Slide mounting hardware kit, CPN 623-5818-001	711.2 (28)	355.6 (14)	203 (8)	5.44 (12)

*Includes packing material.

b. Keep wires and cables away from circuits carrying heavy currents, pulses, and other sources of interference.

c. Unless otherwise indicated on the installation wiring diagram, mating connectors are designed to accept up to #20 AWG wire size.

d. Maximum run length between RT-980/GRC-171 and C-7999/GRC-171 should not exceed 45.7 m (150 ft) when using unshielded wire. When using twisted, shielded pairs, the cable run can be extended from 45.7 m (150 ft) to a maximum of 305 m (1000 ft) providing the requirements of figure FO-2, chapter 6, are met.

2-17. ENVIRONMENTAL CONSIDERATIONS.

2-18. There are no special environmental considerations for installation and operation of the RT-980/ GRC-171 or the C-7999/GRC-171. TheRT-980/GRC171 is convection cooled and is designed to operate at room ambient temperature. Minimum spacing between units is 88.9 mm (3.5 in). However, do not mount the RT-980/GRC-171 over equipment, including other Radio Receiver-Transmitters RT-980/GRC171, that produce substantial amounts of heat such that the ambient temperature for any one RT-980/ GRC-171 can rise above 60 C. The ambient operating temperature range and other environmental characteristics are given in table 1-1.

SECTION III
INSTALLATION PROCEDURES

2-19. MOUNTING.

2-20. RADIO RECEIVER-TRANSMITTER RT-980/GRC-171.

2-21. The RT-980/GRC-171 mounts in a standard 482.6-mm (19-in) rack cabinet. The unit requires 222.3 mm (8.75 in) of vertical clearance and 546.1 mm (21.50 in) of front-to-rear clearance as shown in figure FO-1. To mount the unit, proceed as follows:

NOTE

Slide rails are attached to the RT-980/ GRC 171 at the factory. The cabinet mounted slides are contained in slide mounting hardware kit, Collins part number 623-5818-001. Inventory the slide mounting hardware kit using figure FO-1 prior to installing the kit. The kit contains four slide brackets designated as front left, front right, rear left, and rear right. The brackets are easily identified by comparing the part number stamped on each bracket with figure FO-1.

a. Mount slides in cabinet using hardware provided. Refer to figure FO-1.

b. Install RT-980/GRC-171 on slides in cabinet.

c. Install ground wire on lug provided at rear of unit.

CAUTION

Do not apply primary power to unit until after checking primary power strapping. Refer to primary power strapping, para- graph 2-26 and figure 2-2.

d. Connect cables to A100A2J6, A100J7, A100A2J8 (if used), A10A2J9, and A10A2J22 at rear of unit.

e. At front panel, verify that the coaxial jumper is connected between ANT and XCVR jacks.

NOTE

Do not secure unit until after initial setup has been performed.

f. Slide unit into rack and secure with four screws and flat washers provided by the user.

2-22. RADIO SET CONTROL C-7999/GRC-171.

2-23. The C-7999/GRC-171 maybe mounted anywhere within 305 m (1000 ft) of the RT-980/GRC-171. Refer to paragraph 2-14 for cable requirements. The mounting space required by the front panel is 82.6 mm (3.25 in) wide by 66.7 mm (2.62 in) high as shown in figure 2-1. Front-to-rear clearance required allowing for the mating connector is at least 152.4 mm (6.00 in). To mount the C-7999/ GRC-171, proceed as follows:

NOTE

The C-7999/GRC-171 is designed to mount in an existing user-supplied panel. If it should be necessary to cut a mounting hole, refer to panel mounting detail of figure 2-1 for dimensions. Drill screw holes for 4-40 tap or use #27 clearance drill.

a. Connect mating connector to J1 at rear of unit.

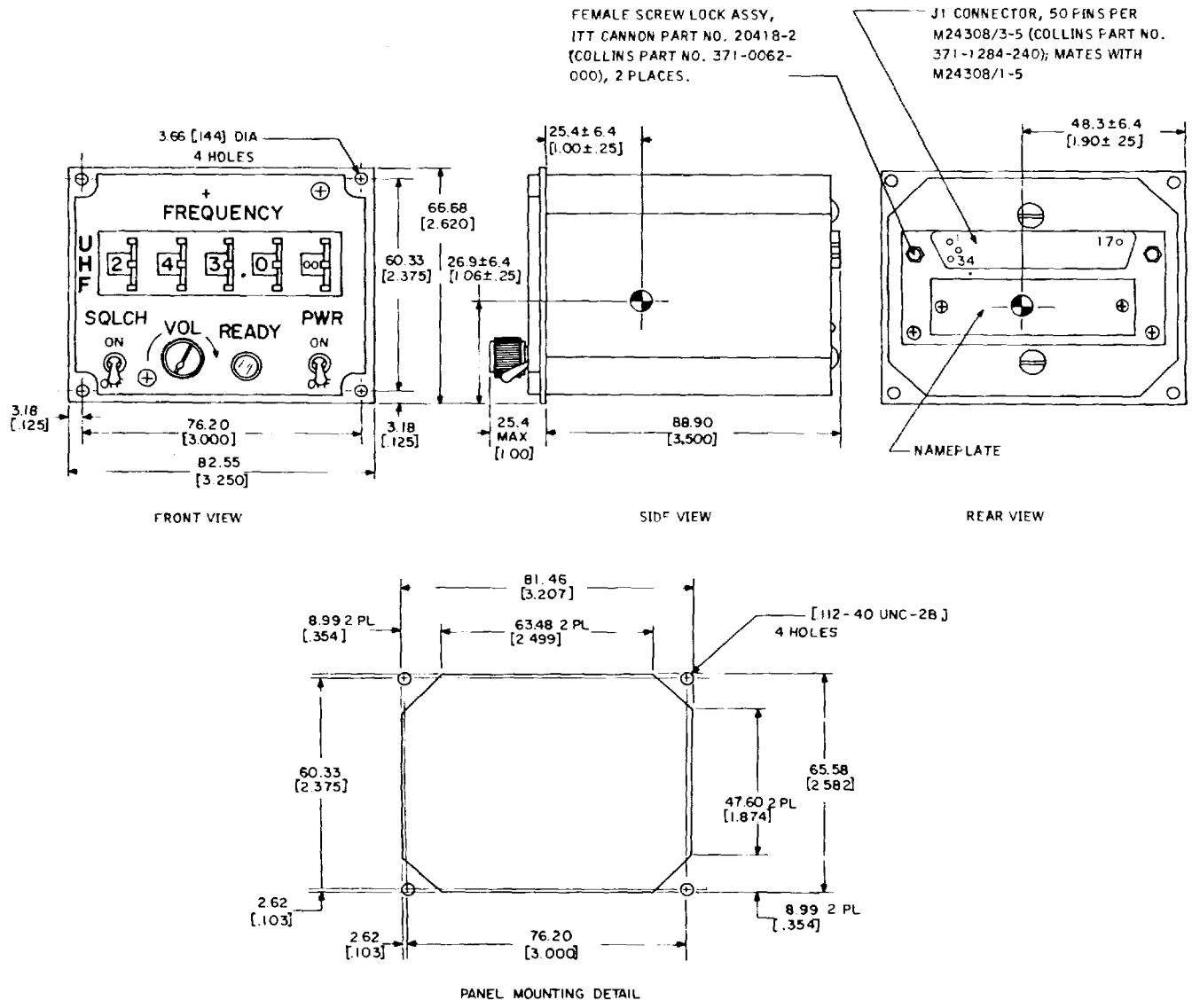
b. Fasten unit in place with four 4-40 roundheaded screws and lockwashers.

2-24. INITIAL SETUP PROCEDURE.

2-25. The initial setup procedures ensure that the RT-980/GRC-171 matches the operational requirements of the user station. There are no initial setup procedures for the C-7999/GRC-171.

CAUTION

Do not apply primary power to the RT-980/ GRC-171 until primary power strapping has been checked. Refer to paragraph 2-26 and figure 2-2.



NOTES:

1. DIMENSIONS ARE IN MILLIMETRES [INCHES].
2. UNIT WEIGHT IS 0.680kg [1.50] POUNDS MAX.
3. CENTER OF GRAVITY INDICATED BY ⊕
4. LIGHTING PANEL AND MOUNTING PLATE FINISHED WITH BLACK LUSTERLESS ENAMEL PER COLOR NO. 37038 OF FED-STD-595; COVER FINISHED WITH ZINC CHROMATE PRIMER PER MIL-P-8585.

CONNECTOR J1 WIRING

PIN	FUNCTION	PIN	FUNCTION	PIN	FUNCTION
1	100 MHZ SELECT	18	AUDIO COMMON	35	GROUND
2	80 MHZ SELECT	19	SQUELCH ON/OFF	36	GROUND
3	40 MHZ SELECT	20	GROUND	37	-0.7V RETURN
4	20 MHZ SELECT	21	SPARE	38	-0.7V RETURN
5	10 MHZ SELECT	22	REMOTE ON/OFF	39	-0.7V RETURN
6	8 MHZ SELECT	23	READY	40	-0.7V RETURN
7	4 MHZ SELECT	24	+26 VDC	41	-0.7V RETURN
8	2 MHZ SELECT	25	SPARE	42	+26 VDC ILLUM PNL
9	1 MHZ SELECT	26	SPARE	43	SPARE
10	0.8 MHZ SELECT	27	SPARE	44	SPARE
11	0.4 MHZ SELECT	28	SPARE	45	SPARE
12	0.2 MHZ SELECT	29	SPARE	46	SPARE
13	0.1 MHZ SELECT	30	SPARE	47	SPARE
14	50 KHZ SELECT	31	SPARE	48	SPARE
15	25 KHZ SELECT	32	SPARE	49	SPARE
16	AUDIO INPUT	33	SPARE	50	SPARE
17	AUDIO OUTPUT	34	SPARE		

TP3-7664-014

Figure 2-1. Radio Set Control C-7999/GRC-171, Outline and mounting Diagram

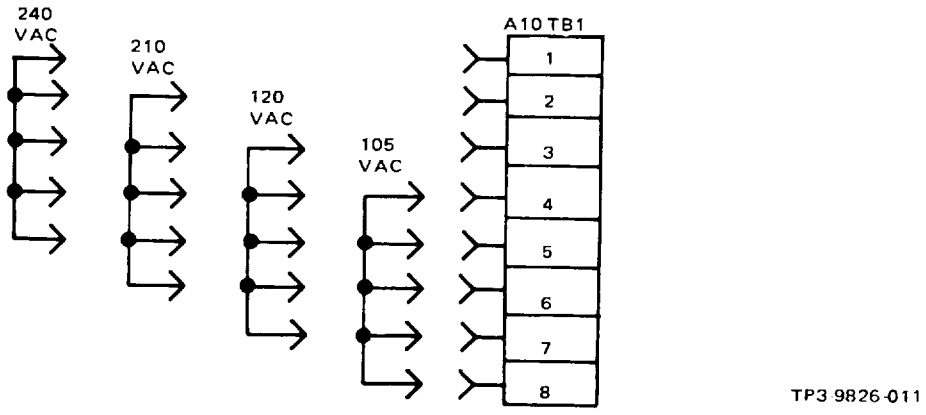


Figure 2-2. Primary Power Strapping

2-26. PRIMARY POWER STRAPPING.

a. Extend RT-980/GRC-171 on the rack slides and remove the top cover.

b. Check to ensure that the strapping on A10TB1 matches the station primary power supply. Change if necessary. Refer to figure 2-2.

2-27. AUDIO MODULE A4 STRAPPING.

2-28. The audio module A4 has strapping options for audio input level and transmitter keying. Audio input level strapping provides for normal level (-15 to +10 dB mW) and -35 dB mW (-35 to -15 dB mW) audio inputs. The transmitter is normally keyed by applying a ground or dc voltage to the center tap of the audio input line transformer (A10A2J22-D/E) as determined by the strapping on audio module A4. The strapping options for audio input level and transmitter keying are listed in figure 2-3. To verify or change strapping option, proceed as follows:

a. Remove audio module A4. (Refer to removal/ replacement procedures in chapter 5, section I, of this manual.)

b. Verify that strapping matches station requirements. Refer to figure 2-3. Change if necessary.

c. Replace audio module A4.

2-29. KEYER MODULE A9

2-30. The keyer module provides a tone/VOX keying option, current keying option, and four voltage keying options. Tone/VOX keying option and the four voltage keying options are determined by strapping on the keyer module and are shown in figure 2-4. To verify or change the strapping, proceed as follows:

a. Remove keyer module A9. (Refer to removal/' replacement procedures in chapter 5, section I, of this manual.)

b. Verify that strapping matches station requirements. Refer to figure 2-4. Change if necessary.

c. Replace keyer module.

2-31. NOISE BLANKER (P/O RECEIVER RF MODULE A3).

2-32. The noise blanker provides muting of the receiver from impulse noise received at the antenna. The noise blanker has two strapping options. The strapping options are listed in figure 2-5. To verify or change the strapping, proceed as follows:

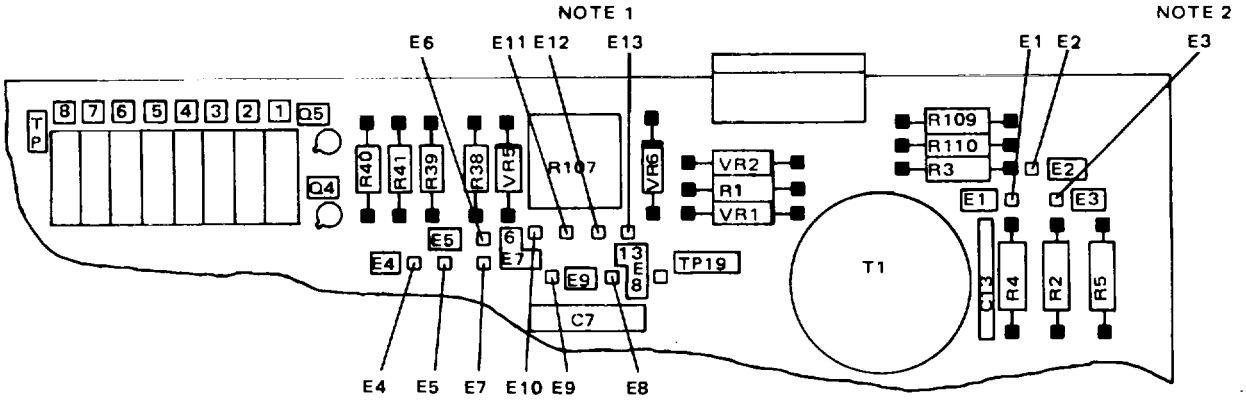
a. Remove receiver rf module A3 (refer to removal/ replacement procedures in chapter 5, section I, of this manual).

b. Verify that strapping matches station requirements. Refer to figure 2-5. Change if necessary.

c. Replace receiver rf module A3.

2-33. INITIAL CHECKOUT PROCEDURE.

2-34. Upon completion of the installation and initial setup procedures, check to ensure that the equipment is operating properly by performing the operating instructions in chapter 3, section II, of this manual.



NOTES:

1. KEYING STRAPPING OPTIONS:

KEYED BY	STRAPPING
GROUND	E4 TO E5, E6 TO E7, E8 TO E9, (E10, E11, E12, E13, OPEN)
+6 V DC	E10 TO E13, (E4, E5, E6, E7, E8, E9, E11, E12 OPEN)
+26 V DC	E11 TO E13, (E4, E5, E6, E7, E8, E9, E10, E12 OPEN)
+48 V DC	E12 TO E13, (E4, E5, E6, E7, E8, E9, E10, E11 OPEN)

2. AUDIO LEVEL STRAPPING OPTIONS:

LEVEL	STRAPPING
NORMAL	E2 TO E3, (E1 OPEN)
-35 DBM	E1 TO E2, (E3 OPEN)

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Figure 2-3. Audio Module A4, Strapping Options Diagram

NOTES:

1. KEYER MODULE STRAPPING OPTIONS:

KEYED BY	STRAPPING
AUDIO KEYING (A10A2J22-T/U)	
TONE VOX	E7, E8 OPEN E7 TO E8
VOLTAGE KEYING (A10A2J22-X/Y)	
6 V DC	E1, E2, E3, E4, E5, E6 OPEN
26 V DC	E5 TO E6 (E1, E2, E3, E4 OPEN)
48 V DC	E3 TO E4 (E1, E2, E5, E6 OPEN)
100 V DC	E1 TO E2 (E3, E4, E5, E6 OPEN)

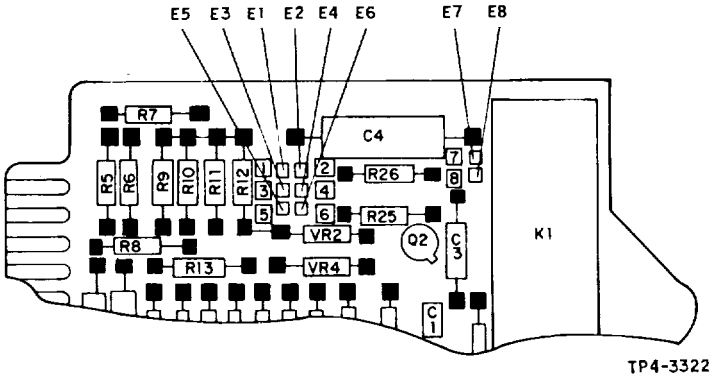

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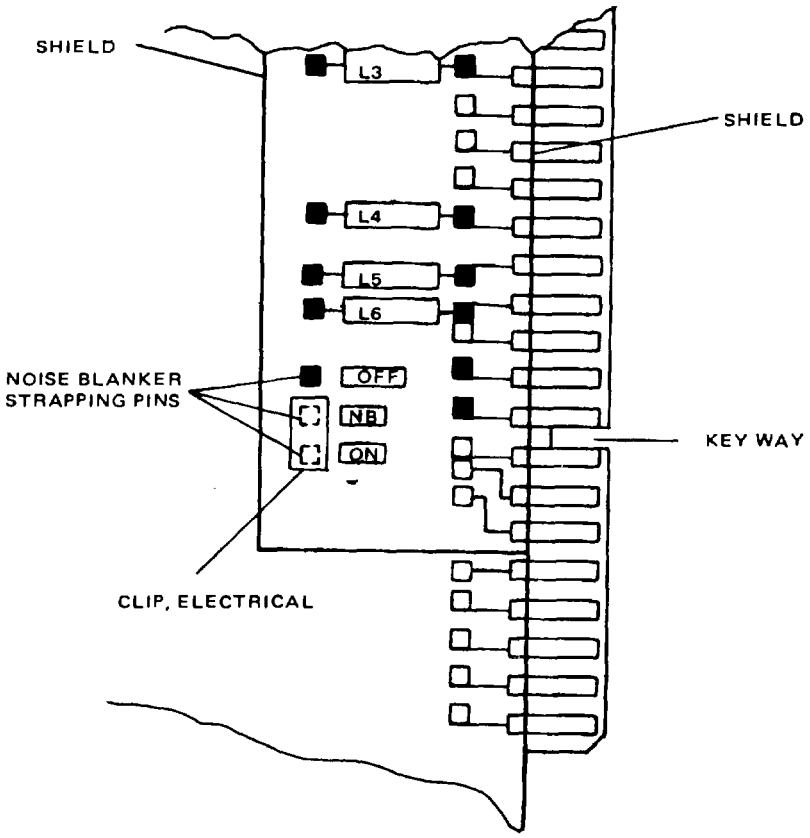
Figure 2-4. Keyer Module A9, Strapping Options Diagram



NOTES:

1. NOISE BLANKER ON: CLIP, ELECTRICAL PLACED ON PINS "NB" AND "ON".
2. NOISE BLANKER OFF: CLIP, ELECTRICAL PLACED ON PINS "NB" AND "OFF".
3. CLIP, ELECTRICAL: BUSSCO ENGINEERING INC. PN 85171-150-2G.

TP4-0810-011

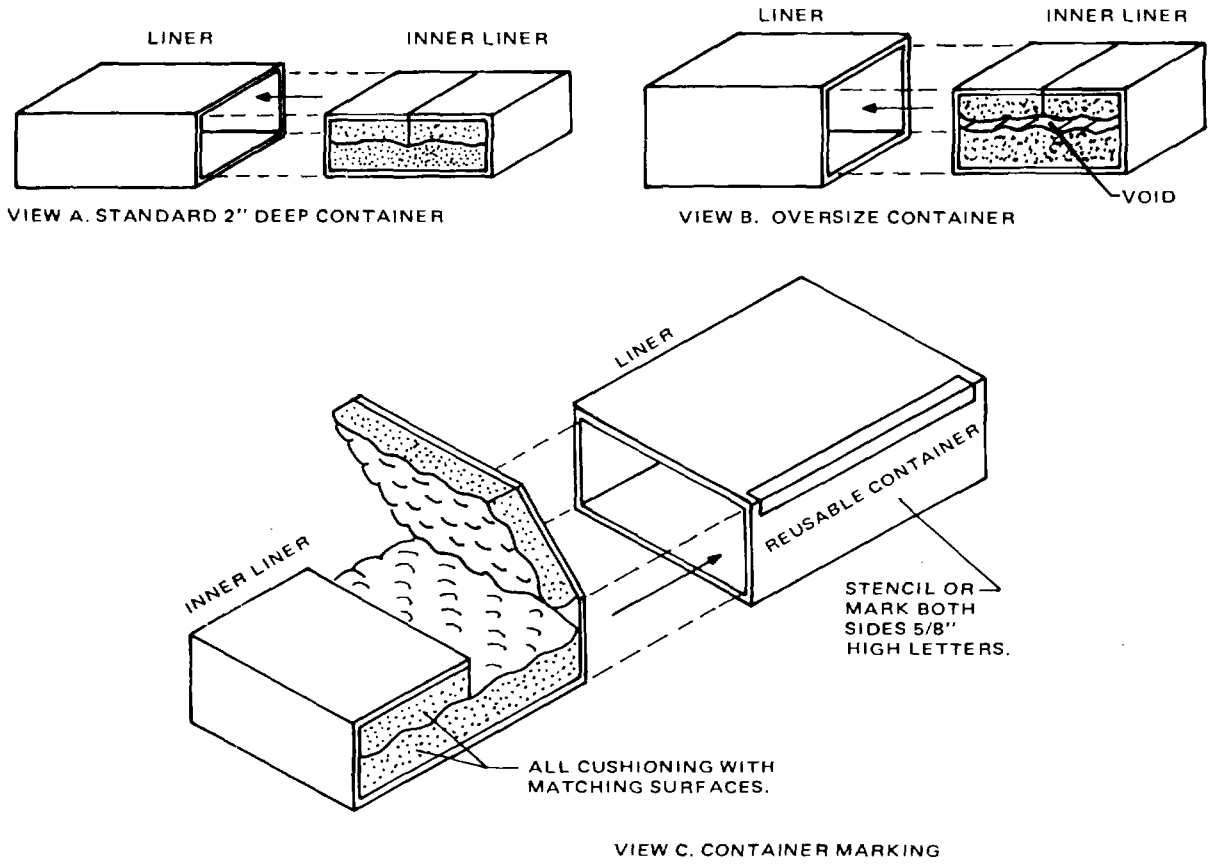
Figure 2-5. Noise Blanker (P/O Receiver RF Module A3), Strapping Options Diagram

SECTION IV
PREPARATION FOR RESHIPMENT

2-35. PREPARATION FOR RESHIPMENT.

2-36. No special procedures are necessary for crating Radio Set AN/GRC-171 reshipment. Repack the radio set in a suitable container that will meet the requirements. Make certain that each unit, including the hardware and rack slides, are held securely in place. Include a packing list that itemizes the contents of the container. The equipment should be itemized in terms of individual components as shown in table 2-1.

2-37. Standard packaging procedures for electronic equipment should be followed in preparing the RT980/GRC-171 modules for reshipment. Refer to figure 2-6 for one method of properly packaging modules for reshipment. Make certain that the module, including pendant cabling when applicable, is held securely in place. Include a packing list that itemizes the contents of the container.



NOTES:

1. CUSHIONING MATERIAL: 2-INCH MATCHED CONVOLUTED POLYURETHANE “ETHER” (OVAL-EGG SHAPED), 1.15 DENSITY, ILD 18-24 POUNDS

2. MATERIAL REQUIREMENTS SHALL BE CORRUGATED, DOMESTIC, SINGLE WALL, 200 LBS BURSTING STRENGTH, B-FLUTE FIBERBOARD CONFORMING TO FEDERAL SPECIFICATION PPP-F-320.

3. THE STANDARD 2-INCH DEEP CONTAINER WILL ACCOMMODATE AN ITEM UP TO ONE INCH THICK. ANY THICKNESS OR DEPTH OVER ONE INCH WILL REQUIRE THAT AMOUNT TO BE ADDED TO THE CONTAINER DEPTH (EXAMPLE AN ITEM HAVING 2 INCH DEPTH WILL REQUIRE THE CONTAINER TO BE 3 INCHES IN DEPTH).

4. TWO INCHES MUST ALWAYS BE ADDED TO THE ITEM LENGTH AND WIDTH TO OBTAIN CORRECT CONTAINER SIZE FOR THE ITEM (EXAMPLE ITEM SIZE MAXIMUM DIMENSIONS 10" L X 8" W X 2 1/4"D WILL REQUIRE CONTAINER SIZE INNER DIMENSIONS 12" L X 10" W X 3 1/4"D).

5. THICKNESS OF POLYURETHANE FOAM WILL ALWAYS BE 2 INCHES REGARDLESS OF THE CONTAINER DEPTH (VIEW B SHOWS A VOID).

6. MAXIMUM WEIGHT OF AN ITEM TO BE PACKED IN THIS CONTAINER SHOULD NOT EXCEED 5 POUNDS.

TP4 0632-011

Figure 2-6 . Module Packaging Instructions

CHAPTER 3
OPERATION

INTRODUCTION

This chapter provides all the information necessary to operate RadioSetAN/GRC-171. Section I describes the operating controls and indicators for Radio Receiver-Transmitter RT-980/GRC-171 and Radio Set Control C-7999/GRC-171. Section H1 provides operating instructions. Section HI provides emergency operating instructions.

SECTION I
CONTROLS AND INDICATORS

3-1. The operating controls and indicators for the RT-980/GRC-171 and the C-7999/GRC-171 are shown in figures 3-1 and 3-2 and described in table 3-1.

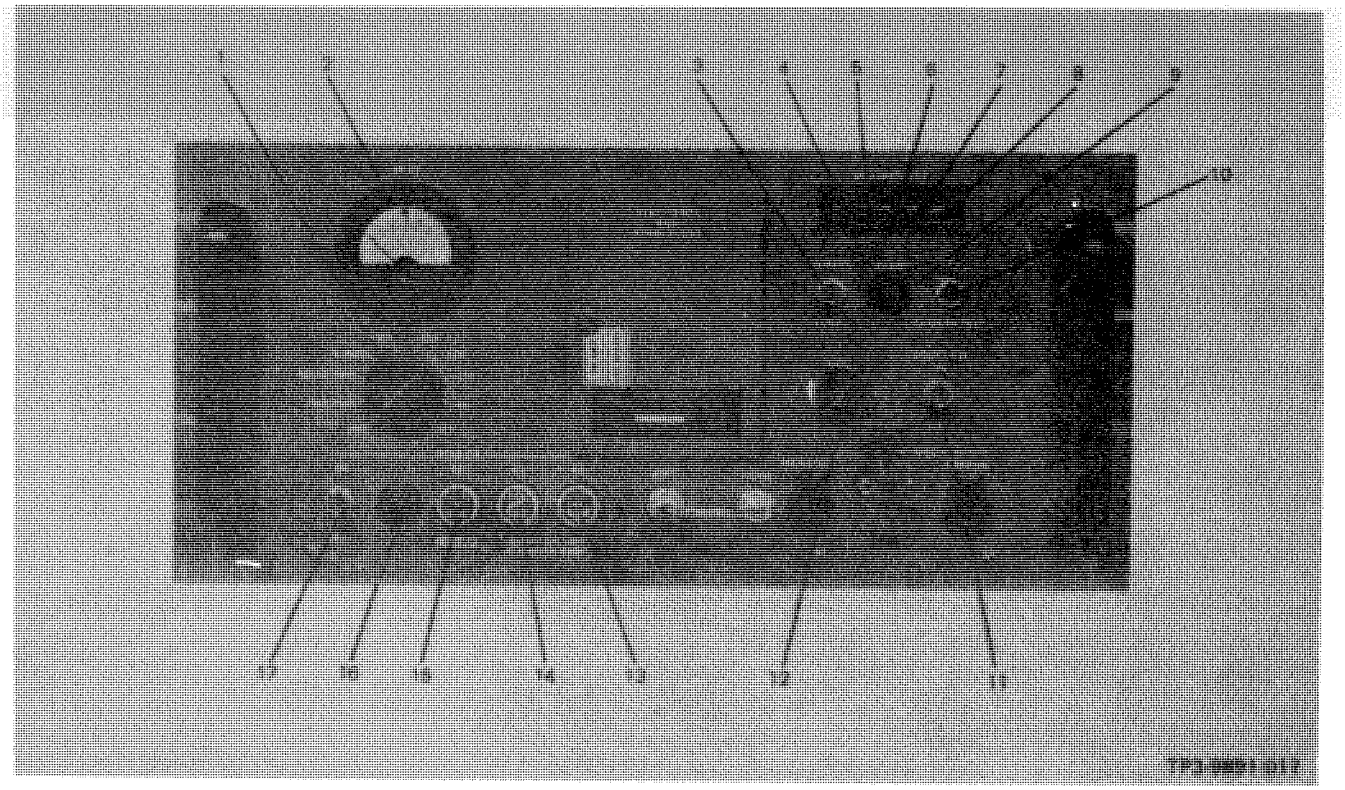


Figure 3-1. Radio Receiver-Transmitter RT-980/GRC-171 Controls and Indicators

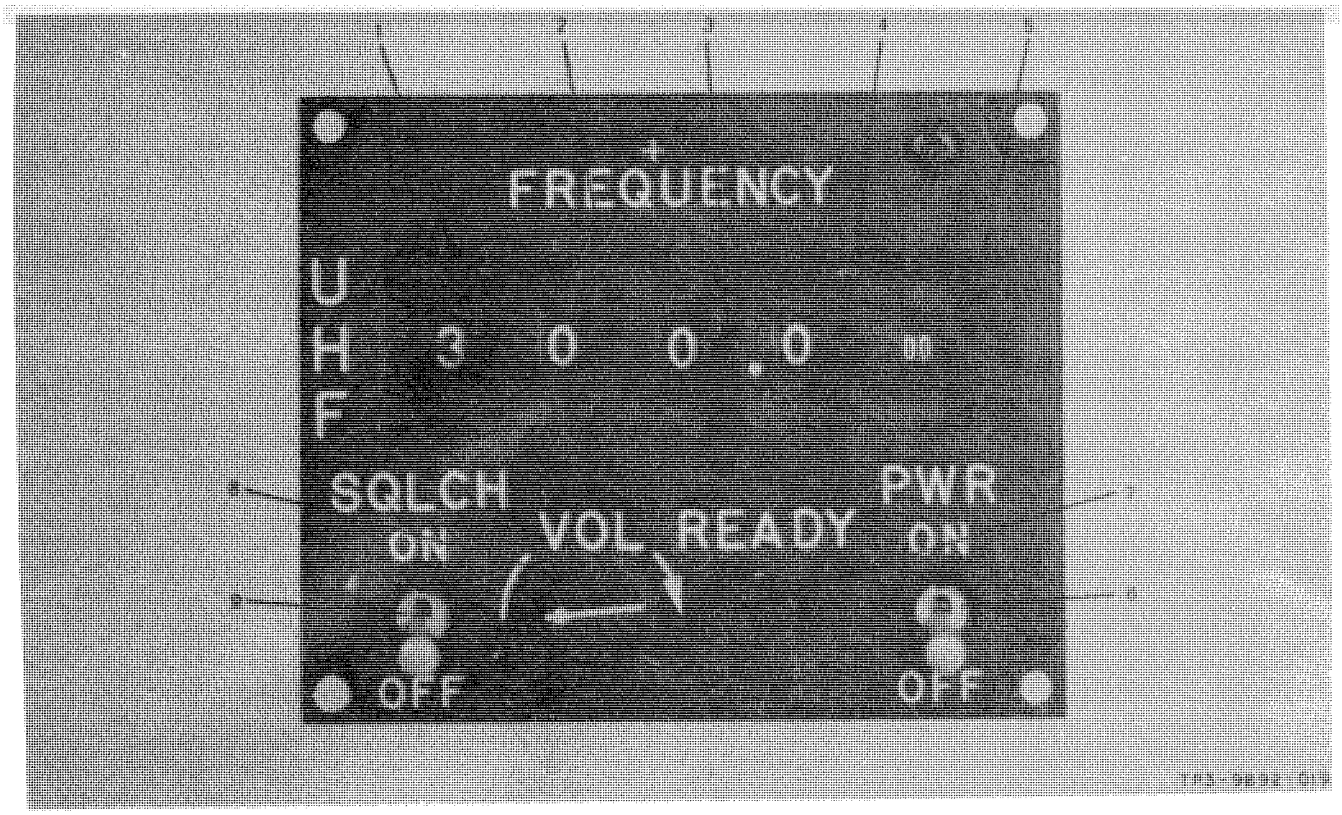


Figure 3-2. Radio Set Control C-7999/GRC-171 Controls and Indicators

Table 3-1. AN/GRC-171 Controls and Indicators (Sheet 1 of 4)

INDEX	CONTROL OR INDICATOR	REFERENCE DESIGNATION	FUNCTION
RADIO RECEIVER-TRANSMITTER RT-980/GRC-171 (Figure 3-1)			
1	TEST switch	A10A1S2	12-position rotary switch. Selects OFF or 1 of 9 inputs to TEST meter as follows: FWD PWR REFLD PWR % MOD TEMP +26V +22V +12V +5V -12V
2 (Cont)	TEST meter	A10A1M1	Multiscale meter. Presents visual indication of signals selected by TEST switch S2 as follows: FWD PWR and REFLD PWR on WATTS scale.

Table 3-1. AN/GRC-171 Controls and Indicators (Sheet 2 of 4)

INDEX	CONTROL OR INDICATOR	REFERENCE DESIGNATION	FUNCTION
RADIO RECEIVER-TRANSMITTER RT-980/GRC-171 (Figure 3-1) (Cont)			
2 (Cont)			% MOD on % scale. TEMP on OVER TEMP scale. +26V and +22V on 30 VOLT scale. +12V and -12V on 15 VOLT scale. +5V on 6 VOLT scale.
3	REMOTE/LOCAL switch	A10A1S3	Toggle switch. Selects remote or local operation.
4	MEGAHERTZ switch	A10A1S6	8-position thumb-wheel switch. Selects tuned frequency in 100-MHz steps.
5	MEGAHERTZ switch	A10A1S7	10-position thumb-wheel switch. Selects tuned frequency in 10-MHz steps.
6	MEGAHERTZ switch	A10A1S8	10-position thumb-wheel switch. Selects tuned frequency in 1-MHz steps.
7	MEGAHERTZ switch	A10A1S9	10-position thumb-wheel switch. Selects tuned frequency in 0.1-MHz steps.
8	MEGAHERTZ switch	A10A1S10	8-position thumb-wheel switch. Selects tuned frequency in 25-kHz steps. NOTE MEGAHERTZ switches S6 through S10 are operative only when REMOTE/LOCAL switch S3 is in the LOCAL position.
9	READY	A10A1DS2	Indicator lamp. When lit, indicates tuning complete. NOTE READY lamp DS2 is operative only when REMOTE/LOCAL switch S3 is in the LOCAL position.
10	PTT/CARRIER TEST switch	A10A1S4	Toggle switch. Selects push-to-talk or continuous carrier operation. NOTE PTT/CARRIER TEST switch S4 is operative only when REMOTE/LOCAL switch S3 is in LOCAL position.

Table 3-1. AN/GRC-171 Controls and Indicators (Sheet 3 of 4)

INDEX	CONTROL OR INDICATOR	REFERENCE DESIGNATION	FUNCTION
RADIO RECEIVER-TRANSMITTER RT-980/GRC-171 (Figure 3-1) (Cont)			
11	SQUELCH ON/ OFF switch	A10A1S5	Toggle switch. Selects squelch operation. NOTE SQUELCH ON/OFF switch S5 is operative only when REMOTE/LOCAL switch S3 is in LOCAL position.
12	VOL	A10A1R1	Potentiometer. Controls audio output level to HEADSET jack J3 and DYNAMIC jack J4.
13, 14	POWER AC	A10A1F2, A10A1F3	Indicator fuseholders. When lit, indicates ac power fuse is blown.
15	POWER DC	A10A1F1	Indicator fuseholder. When lit, indicates dc power fuse is blown.
16	POWER	A10A1DS1	Indicator lamp. When lit, indicates dc-to-dc converter is operating.
17	POWER ON/OFF switch	A10A1S1	Toggle switch. Applied ac or dc primary power to the receiver-transmitter power supply.
RADIO SET CONTROL C-7999/GRC-171 (Figure 3-2)			
1	FREQUENCY switch	S7	8-position thumb-wheel switch. Selects tuned frequency in 100-MHz steps.
2	FREQUENCY switch	S6	10-position thumb-wheel switch. Selects tuned frequency in 10-MHz steps.
3	FREQUENCY switch	S5	10-position thumb-wheel switch. Selects tuned frequency in 1-MHz steps.
4	FREQUENCY switch	S4	10-position thumb-wheel switch. Selects tuned frequency in 0.1-MHz steps.
5	FREQUENCY switch	S3	8-position thumb-wheel switch. Selects tuned frequency in 25-kHz steps. NOTE FREQUENCY switches S3 through S7 are operative only when REMOTE/LOCAL switch S3 on RT-980/GRC-171 is in the REMOTE position.

Table 3-1. AN/GRC-171 Controls and Indicators (Sheet 4 of 4)

INDEX	CONTROL OR INDICATOR	REFERENCE DESIGNATION	FUNCTION
RADIO RECEIVER-TRANSMITTER RT-980/GRC-171 (Figure 3-2) (Cont)			
6	PWR ON/OFF switch	S1	Toggle switch. Enables receiver-transmitter dc-to-dc converter. NOTE PWR ON/OFF switch S1 is operative only when RT-980/GRC-171 POWER ON/OFF switch SI is in the ON position.
7	READY	DS1	Indicator lamp. When lit, indicates receiver-transmitter tuning complete. NOTE READY lamp DS1 is operative only when REMOTE/LOCAL switch S3 on RT-980/GRC-171 is in the REMOTE position.
8	VOL	R1	Potentiometer. Controls receiver-transmitter audio output level at remote speaker or headset location.
9	SQLCH ON/OFF switch	S2	Toggle switch. Selects squelch operation. NOTE SQLCH ON/OFF switch S2 is operative only when REMOTE/LOCAL switch S3 on RT-980/GRC-171 is in the REMOTE position.

SECTION II
OPERATING INSTRUCTIONS

3-2. GENERAL.

3-3. The operating instructions are divided into three parts: local operation, remote operation, and emergency operation. Local operation is primarily for checkout and servicing. The normal mode of opera- tion is remote. The operation of the AN/GRC-171 in local or remote is the same for either standard bandwidth or wide-band (secure voice) data. Emer- gency operation describes certain steps that can be taken to establish or maintain communication under adverse operating conditions. If at any time the opera- tion of this unit becomes abnormal, refer to the performance tests in chapter 5, section I, of this manual.

3-4. LOCAL OPERATION.

3-5. The following paragraphs provide operating instructions for local (front panel) operation of the RT-980/GRC-171.

3-6. PRELIMINARY SETUP.

a. At RT-980/GRC-171 front panel, set switches and controls to the following positions:

CONTROL/SWITCH	POSITION
POWER ON/OFF	OFF
TEST	OFF
REMOTE/LOCAL	LOCAL
PTT/CARRIER TEST	PTT
VOL	Approx 1/4 turn cw
SQUELCH ON/OFF	OFF

b. Connect headset and microphone to appropriate front panel jacks.

3-7. OPERATION.

a. Set POWER ON/OFF switch to ON. Verify that POWER indicator lamp lights.

NOTE

Allow approximately a 2-minute warmup and then proceed with operating instructions.

b. Set TEST switch to the following positions and verify proper indications on VOLT scale of TEST meter.

SWITCH POSITION	NORMAL INDICATION
+26V	26 (±1.5)
+22V	22 (±1.5)
+12V	12 (±1.0)
+5V	5.1 (±0.5)
-12V	12 (±1.0)

c. Set MEGAHERTZ switches to an authorized operating frequency. Observe that the READY lamp lights.

d. Adjust VOL control for suitable headset reception. If squelch operation is desired, set SQUELCH ON/OFF switch to ON.

NOTE

When PTT/CARRIER TEST switch is set to CARRIER TEST position, any audio input will be transmitted.

NOTE

Before transmitting, the operator must be certain that the equipment is operating on an authorized frequency.

e. Set PTT/CARRIER TEST switch to CARRIER TEST position.

f. Set TEST switch to FWD PWR position. TEST meter should indicate 16 to 24 on the WATTS scale.

g. Set TEST switch to REFLD PWR position. Test meter should indicate 0 to 25 percent of FWD PWR.

h. Return PTT/CARRIER TEST switch to PTT position.

i. Set TEST switch to % MOD position.

j. Key transmitter and observe TEST meter while speaking into microphone. Needle deflection between 0 and 95 on % scale indicates carrier modulation. When transmission is complete, release key.

k. Set TEST switch to OFF position.

l. To shut down the RT-980/GRC-171, set POWER ON/OFF switch to OFF.

3-8. REMOTE OPERATION.

3-9. The following paragraphs provide operating instructions for remote operation of the RT-980/ GRC-171 from the C-7999/GRC-171.

3-10. PRELIMINARY SETUP.

a. At C-7999/GRC-171 front panel, set switches and controls as follows:

CONTROL/SWITCH	POSITION
PWR ON/OFF	OFF
SQLCH ON/ OFF	OFF
VOL	Approx 1/4 turn cw

b. At RT-980/GRC-171 front panel, set switches and controls as follows:

CONTROL/SWITCH	POSITION
REMOTE/LOCAL	REMOTE
TEST	OFF
POWER ON/OFF	ON (POWER lamp will not light until PWR ON/OFF switch at C-7999/GRC-171 is set to ON.)

NOTE

The READY indicator and PTT/CARRIER TEST, SQUELCH ON/OFF, and MEGAHERTZ switches on RT-980/GRC-171 front panel are inoperative as long as REMOTE/LOCAL switch is in REMOTE.

3-11. OPERATION.

a. At Radio Set Control C-7999/GRC-171, set PWR ON/OFF switch to ON. READY lamp lights.

NOTE

Allow approximately a 2-minute warmup and then proceed with operating instructions.

b. Set FREQUENCY switches to an authorized operating frequency. Observe that READY lamp is lit.

c. Adjust VOL control for suitable headset reception. If squelch operation is desired, set SQLCH ON/OFF switch to ON.

NOTE

Before transmitting, the operator must be certain that the equipment is being operated on an authorized frequency.

d. To transmit, key transmitter and speak into microphone. When transmission is complete, release key.

e. To shut down the RT-980/GRC-171, set PWR ON/OFF switch on C-7999/GRC-171 to OFF.

SECTION III
EMERGENCY OPERATION

3-12. EMERGENCY OPERATION.

3-13. 2-MINUTE WARMUP.

3-14. Under emergency conditions, the 2-minute warmup time may be omitted and the unit placed into immediate operation.

3-15. OVERTEMPERATURE CONDITION.

3-16. Under extremely adverse environmental and operating conditions the RT-980/GRC-171 may go into the overtemperature operating mode. This condition is determined by setting the TEST switch to TEMP and observing an indication in the OVER TEMP range on the TEST meter. When this condition occurs, the output power from the unit is automatically reduced to approximately 4 watts. Should this condition occur, check the rack ventilation or provide additional ventilation as required.

3-17. BATTERY OPERATION.

3-18. With an external battery connected to the RT-980/GRC-171, if ac power failure occurs, the RT-980/GRC-171 automatically switches to battery power without an interruption to the receiver- transmitter operation. The unit will continue to operate on battery power until ac power is reapplied to the receiver-transmitter. Radio Set AN/GRC-171 will function normally on both receive and transmit operation.

CHAPTER 4
PRINCIPLES OF OPERATION

4-1. INTRODUCTION.

4-2. This chapter contains a discussion of Radio Set AN/GRC-171 based on functional block diagrams, simplified schematic diagrams, and complete schematic diagrams of the equipment. Section I covers the AN/GRC-171 on an overall functional basis. Sec- tion II provides detailed coverage of electronic circuits. Section III covers operating theory of mechani- cal assemblies. Refer to TO 31-1-141 for principles of operation of basic electronic circuits. Unless otherwise indicated, the discussion and figures in this chapter cover the latest effectivities. Where differences in effectivities are minor (value changes, slight changes in circuit configuration, etc), they are not discussed.

SECTION I
FUNCTIONAL SYSTEM OPERATION

4-3. GENERAL.

4-4. This section discusses the overall system operation of Radio Set AN/GRC-171 followed by a discus- sion of the transmit, receive, and power distribution functions. Also discussed is system keying and dis- able circuits along with frequency control circuits. Figure FO-3 shows an overall block diagram of the AN/GRC-171. Figure FO-16 shows transmit signal flow of the transmitter section, and figure FO-15 shows receive signal flow of the receiver section of the AN/GRC-171. Figure FO-14 shows power dis- tribution of the overall radio set. Power distribution will be discussed in detail in this section.

4-5. OVERALL SYSTEM OPERATION.

4-6. Refer to figure FO-3. The radio set is capable of transmitting or receiving either narrow-band voice audio or wide-band data (including secure voice data) on 1 of 7000 channels (25-kHz channel spacing) in the ultrahigh-frequency (uhf) band of 225.000 to 399.975 MHz. The radio set can be operated either locally by controls located on the front panel of Radio Receiver-Transmitter RT-980/ GRC-171 (receiver-transmitter) or remotely by controls located on Radio Set Control C-7999/GRC-171 (radio control). For the purpose of this general discussion, assume the system is operated remotely from the radio control. The radio set can be powered from either a 120- or 240-V ac power line or from a 22- to 30-V dc source or from a 24-V dc battery.

4-7. The receiver-transmitter consists of a receiver section (lower half of figure FO-3) and a transmitter section (upper half of figure FO-3). Through a transmit/receive switch, the transmitter and receiver share a common rf filter at the antenna port of the receiver-transmitter. The rf filter is tuned to the radio control frequency so that it passes only the desired transmit and receive signals and rejects all other signals. With the exception of the rf filter, the only other common circuits between the receiver section and transmitter section are frequency control, key line, and power supply voltage. Frequency control is provided by a phase-locked loop frequency synthesizer. The phase-locked loop receives binary- coded-decimal (bcd) frequency select information from the radio control and provides through a transmit/ receive switch either a transmit rf signal (225.000 to 399.975 MHz) to the transmitter or a receive injection signal (195.00 to 369.975 MHz) to the receiver. Receiver-transmitter keying is provided by keying circuits that convert remote key information into two transmitter key lines (key 1 and key 2). Power supply voltages are provided by a transformer/ rectifier, two dc-dc converters, and a voltage regulator that together convert input ac power line voltage (or dc input voltage) into regulated power supply voltages.

4-8. The receiver section of the receiver-transmitter is a double-conversion receiver with the first inter- mediate frequency (if) of 30 MHz derived from mixing the incoming receive rf signal with the receive injection signal. The second intermediate frequency of 10.7 MHz is derived from mixing the 30-MHz if signal with a 19.3-MHz oscillator signal. The 10.7-MHz if signal is detected into receive audio. The receive audio is amplified, filtered, and then fed

to the headset output and audio (or data) output of the receiver-transmitter. Impulse type noise is blanked from the audio output by a noise channel blanking circuit in the 30-MHz if circuit. Receive squelch is provided by a squelch circuit in the audio circuit. Receiver selectivity is determined by a crystal filter in the 10.7-MHz if circuit. Audio (or data) response is determined by active filters in the audio circuit. The crystal filter (36-kHz bandwidth) supplied with the radio set provides for 50-kHz channel spacing. An optional narrow bandwidth (20-kHz) or wide bandwidth data (60-kHz) filter can be installed for 25-kHz channel spacing or 100-kHz channel spacing respectively. Noise channel blanking is disabled when the wide bandwidth filter is installed.

4-9. The transmitter section of the receiver- transmitter contains a broadband rf amplifier that amplifies the transmit rf signal from the frequency synthesizer to provide 16- to 24-watt (nominal 20- watt) carrier power at the antenna. An automatic load control (ALC) circuit receives forward and reflected power signals to maintain control of the power output level. The transmit rf signal is amplitude modulated by input audio (or data) that is amplified, filtered, and applied to the modulator of the power amplifier. Harmonics in the transmit rf signal are attenuated by the rf filter.

4-10. A meter circuit in the receiver-transmitter allows measurement (from the front panel) of power supply voltages, antenna forward and reflected powers, the percent modulation of the transmit rf signal, and the relative heat-sink temperature of the power amplifier.

4-11. TRANSMITTER OPERATION.

4-12. Refer to the transmit signal flow diagram of figure FO-16. The transmit section of the receiver-transmitter consists of power amplifier module A8, transmit audio circuits of audio module A4, and the common rf signal path through rf filter module A7. Transmitter keying circuits are contained in audio module A4 and keyer module A9. Tuning for the rf filter of rf filter module A7 is provided by d/a servo amplifier Al.

4-13. For remote operation, three audio inputs can be applied to the transmitter. They are the micro- phone input, audio input, and data input. All three inputs are applied to audio module A4 through the electromagnetic interference (emi) filter on chassis A10 of the receiver-transmitter. For local operation, microphone audio is applied to audio module A4 from jacks located on the front panel (chassis A10) of the receiver-transmitter. The input audio is coupled through transformer T1 to the compression amplifier. The microphone audio is applied directly to the compression amplifier. The compression amplifier amplifies the audio signal and maintains a constant output audio level that will not overmodulate the transmitter. The output of the compression amplifier is passed through a low-pass and high-pass filter that together shape the audio response of the transmit audio signal. The input data signal to be transmitted is fed around the compression amplifier and applied to a second high-pass filter. This filter in conjunction with the low-pass filter following the percent modulation (% MOD) control shapes the frequency response of the transmit data signal. The output of the high- pass filter is applied to the % MOD control located on the front panel of the receiver-transmitter. The % MOD control is adjusted to set the audio level to give the desired percent of modulation of the transmit rf signal. The audio signal from the % MOD control is passed through the clipper/low-pass filter of audio module A4 to the modulator of power amplifier module A8. The clipper removes audio peaks that could overmodulate the transmitter.

4-14 To key the transmitter, push-to-talk (ptt) keying information from the receiver-transmitter front panel REMOTE/LOCAL switch is applied to the keying con- trol circuit of audio module A4. The keying control circuit provides two transmitter key lines, one a fast attack-slow release key line (key 1) and the other a slow attack-fast release key line (key 2). For remote operation, keying from five separate inputs can key the transmitter. They are the audio loop, current loop, and voltage loop keying inputs, the remote ptt key-line input, and the keying information supplied on the audio inputs (CT 1 and CT 2) to the receiver-transmitter. The audio loop, current loop, and voltage keying signals are applied through the emi filter to the keyer circuit of keyer module A9. The remote key output of the keyer is applied to the remote side of the REMOTE/LOCAL switch. The remote pit key line is applied directly to the remote side of the REMOTE/LOCAL switch. Keying information sup- plied on the audio input lines is applied to the remote ptt keyer of audio module A4. The remote ptt output of the remote ptt keyer is applied to the remote side of the REMOTE/LOCAL switch. For local operation, the ptt lines from the MIC jacks and from the PTT/ CARRIER TEST switch on the front panel of the receiver-transmitter are connected to the local side of the REMOTE/LOCAL switch.

4-15. Refer to figure FO-16, sheet 2. The rf signal to be transmitted is generated by the phase-locked loop (p11) of frequency synthesizer module A2. The fre- quency of the rf signal is determined by bcd frequency select information applied to the phase-locked loop from the radio control. During transmit mode, the output of the phase-locked loop is applied to power amplifier module A8 through the frequency synthesizer transmit/receive switch (actually a diode switch) that is closed by the slow attack-fast release transmitter key line (key 2).

4-16. The transmit rf signal (carrier signal) from frequency synthesizer module A2 is applied to the

high-level modulated rf amplifiers in power amplifier module A8 where the rf signal is amplitude modulated by the output of the modulator. The modulated rf signal is then applied to the rf predriver/ALC attenuator where it is attenuated by an ALC control voltage to provide a Constant carrier power output to the antenna. The attenuated rf signal is then amplified by rf power amplifiers and applied through the reflecto-meter to rf filter module A7. The forward and reflected powers of the transmit rf signal from the power amplifier are detected by the reflecto-meter and fed back to the ALC circuit where they are used to develop ALC control voltage.

4-17. The transmit rf signal from power amplifier module A8 is applied through the transmit/receive switch (actually a diode switch) of rf filter module A7 to the rf filter. The transmit/receive switch is closed by the fast attack-slow release transmitter key line (key 1) whenever the transmitter is keyed. Harmonic content of the transmit rf signal is filtered out by the rf filter which consists of four capacity- tuned resonators that provide a 2-dB bandwidth of about ±1.5 MHz from center frequency and greater than 40 dB of attenuation beyond 7 MHz. The output of the rf filter is applied through the directional coupler to the antenna. The forward and reflected power of the transmit rf signal applied to the antenna are detected by the directional coupler. The detected power signals are amplified and fed back to the ALC circuit where they are used to develop ALC control voltage.

4-18. Although not shown in figure FO-16, the pa and antenna forward and reflected power signals are monitored by a voltage standing-wave ratio (vswr) comparator and a pa/antenna power ratio comparator in the ALC circuit of power amplifier module A8. Also, the heat-sink temperature of the power amplifier module is monitored. If the antenna vswr exceeds 3 to 1, or if the pa power output exceeds the power to the antenna by more than about 2 dB, or if the heat- sink temperature exceeds 100 degrees Celsius, the ALC circuit develops ALC voltage that reduces the rf power output by about 7 dB to approximately 4 watts.

4-19. The servo motor that positions the rf filter is controlled by servo motor drive voltage supplied from d/a servo amplifier module A1. The servo motor drive voltage is developed as follows: Bcd frequency select information from either the local frequency select control or the C-7999/GRC-171 frequency select control is applied to the d/a con- verter of d/a servo amplifier module A1. For each frequency between 225 and 399.975 MHz, the d/a converter develops a unique d/a analog voltage that represents 1 of the 7000 frequency channels. The d/a analog voltage is applied to the d/a servo potentiometer comparator where it is compared to the position feedback signal from the position feedback potentiometer of rf filter module A7. The resulting error voltage from the d/a servo potentiometer comparator is amplified by the servo amplifier to develop the servo motor drive voltage. To tune the rf filter, the servo motor runs until the position feedback signal nulls the output of the d/a servo potentiometer comparator. The center frequency of the rf filter is aligned so that the position feedback signal for each of the 7000 frequency channels tracks the d/a analog voltage. Thus, when the output of the d/a servo potentiometer comparator nulls, the rf filter is tuned to the selected transmit frequency.

4-20. A READY lamp is located on the front panel of the receiver-transmitter and on the C-7999/GRC-171 (figure FO-16, sheet 1). The REMOTE/'LOCAL switch selects the C-7999/GRC-171 READY lamp for remote operation and the front panel READY lamp for local operation. The selected READY lamp is turned on and off by the output of the fault switch of audio module A4. The pll fault signal from the phase-locked loop of frequency synthesizer A2 and the rf filter fault signal from the servo fault amplifier of d/a servo amplifier module Al are applied to the fault switch. The selected READY lamp is turned on by the fault switch whenever the phase-locked loop is locked and the rf filter is tuned to a frequency between 225.000 and 399.975 MHz. The pll fault signal causes the selected READY lamp to turn off if the phase-locked loop is in the process of tuning or if the phase-locked loop malfunctions. The rf filter fault signal causes the selected READY lamp to turn off if the rf filter is in the process of tuning, or if the frequency select control is set to a frequency below 220 MHz, or if the servo amplifier malfunctions. In addition to turning off the selected READY lamp, the fault switch inhibits the key 2 key line to prevent the power amplifier from being keyed on.

4-21. The power amplifier is turned off by the key 2 key line whenever the receiver-transmitter is un-keyed or when the READY lamp is turned off by the fault switch as described above. The key 2 key line is applied to the ALC circuit of power amplifier module A8. When un-keyed, the ALC circuit develops ALC control voltage that causes maximum attenuation to the rf transmit signal. At the same time, the transmit rf signal is removed from the input to the power amplifier module by the transmit/receive switch of the frequency synthesizer module. This turns off the power amplifier. The fast release of key 2 assures that the power amplifier is turned off before the transmit/receive switch of the rf filter module is switched to receive by the slow release of key 1.

4-22. RECEIVER OPERATION.

4-23. Refer to the receive signal flow diagram of figure FO-15. The receive section of the receiver- transmitter consists of receiver rf module A3, receive audio circuits of audio module A4, and the common rf signal path through rf filter module A7. Receive squelch is contained in audio module A4.

4-24. During receive mode, the incoming rf signal from the antenna is applied through the directional coupler to the rf filter of rf filter module A7. To eliminate interference from collocated equipment, the rf filter is tuned (as described in paragraph 4-19) to the radio control frequency. This prevents large out-of-band signals from being applied to receiver rf module A3. The output from the rf filter is applied to the transmit/receive switch (actually a diode type switch) that also acts as an rf attenuator to provide front-end signal attenuation. The amount of attenuation is controlled by the rf attenuation (AGC) signal from the AGC amplifier of receiver rf module A3 and is dependent upon rf signal strength. When the trans- mitter is un-keyed, the slow release of key 1 causes the receive rf output of the rf filter module transmit/ receive switch to be routed to the uhf mixer of receiver rf module A3. Also, when the transmitter is un-keyed, the fast release of key 2 causes the receive injection output of the frequency synthesizer module transmitter receive switch to be routed to the uhf mixer. The receive injection signal is generated by the same phase-locked loop that generates the transmit rf signal. However, when the transmitter is un-keyed, the key 1 key line and the 30-MHz decode circuit of frequency synthesizer module A2 cause the phase- locked loop to shift down in frequency by 30 MHz. This results in a receive injection signal that is 30 MHz less than the selected radio control frequency. The slow release of key 1 assures that the switch to receive mode has been made before the phase- locked loop is shifted in frequency.

4-25. In the receiver rf module, the uhf mixer mixes the receive rf signal (225 to 399.975 MHz) with the receive injection signal (195 to 369.975 MHz) to produce the 30-MHz if signal that is applied to the 30-MHz if amplifier. The 30-MHz if signal is split into two signal paths; one to the second mixer and one to the noise channel. The 30-MHz if signal that is applied to the second mixer is mixed with the 19.3-MHz output signal from the injection amplifier to produce the 10.7-MHz if signal. Impulse type noise that is received at the antenna is routed through the noise channel where it is used to disable the 19.3-MHz oscillator input to the second mixer. This action mutes the receive so that the noise pulse does not appear at the receiver audio output. The output of the second mixer is applied to the 10.7-MHz if amplifier where the 10.7-MHz if signal is amplified and applied to the detector and to the if jack of the receiver- transmitter. The detector demodulates the amplitude modulated signal to produce AGC voltage and the receive audio signal (or data signal) to audio module A4. The AGC voltage is amplified by the AGC amplifiers and applied to the 10.7-MHz if amplifiers, 30- MHz if amplifiers, and to rf filter module A7 to control the gain of the receiver. The receive signal is applied to the bandpass filter. The bandpass filter shapes the frequency response of the receive data signal and applies it to the data output of the receiver-transmitter. The receive signal is also applied to the compression amplifier. The compression amplifier maintains a constant output level for variations in percent modulation of the receive signal. The output of the compression amplifier is passed through a high-pass filter and a low-pass filter that together shape the audio response of the receive audio signal. The output of the low-pass filter is then applied to the receive audio (RCV AUDIO) control and to the headset volume (VOL) control located on the front panel of the receiver-transmitter. The RCV AUDIO control is adjusted to set the receiver-transmitter audio output level, and the VOL control is adjusted to set the headset audio level. The output of the RCV AUDIO control is applied to the 100-milliwatt power amplifier of audio module A4. The output of the power amplifier is transformed into two 150-ohm lines by transformer A4T2 and then applied through chassis A10 emi filter to the audio output of the receiver-transmitter. The output of the VOL control is applied to a second 100-milliwatt power amplifier in audio module A4. The output of this amplifier is transformed into a 600-ohm output by transformer A4T3 and then applied to the headset jack on the front panel of the receiver-transmitter through chassis A10 emi filter to headset audio out (J22-k).

4-26. During the transmit mode, sidetone audio is taken from the output of the forward power amplifier in rf filter module A7 and applied to the SIDETONE control on the front panel of the receiver- transmitter. The output of the SIDETONE control is applied to the compression amplifier to provide sidetone audio in the output audio signal or in the headset during transmit mode.

4-27. For receive squelch, the squelch sample signal developed from AGC voltage is applied to the squelch control circuit of audio module A4. Also applied to the squelch control circuit is the squelch reference input from the SQUELCH control on the front panel of the receiver-transmitter. The squelch control circuit compares the squelch sample signal, which is a function of the level of the incoming rf signal, to the squelch reference input. The output of the squelch control circuit operates the squelch gate to mute the receive audio whenever the incoming rf signal is below the squelch threshold (as set by the SQUELCH control). When operating remotely through the front panel REMOTE/LOCAL switch, the squelch can be disabled by the SQLCH ON/OFF switch of C-7999/ GRC-171. When operating locally, the squelch can be disabled by the front panel SQUELCH ON/OFF switch.

4-28. The output from the squelch control circuit of audio module A4 is also applied to keyer module A9. When the squelch is turned on and the incoming rf signal is above squelch threshold, the squelch com- parator and relay driver circuit of keyer module A9 causes squelch relay A9K1 to energize. The squelch

relay is deenergized if the squelch is turned off, or if the incoming rf signal decreases below squelch threshold, or if the transmitter is keyed (key 1 key line).

4-29. POWER DISTRIBUTION.

4-30. Refer to the power distribution diagram of figure FO-14. The power supply for the receiver- transmitter consists of de-de converter module A5, voltage regulator module A6, and power supply components mounted on chassis A10. Unless otherwise specified, reference designators apply to chassis A10.

4-31. Input ac voltage (J7-B and A) or battery voltage (J7-E and D) is applied to the front panel POWER ON/OFF switch (A10AlSl) through the emi filter and the filter formed from chassis-mounted inductors and capacitors. When the POWER switch is on, ac voltage is applied through fuses A10A1F2 and A10A1F3 to transformer T1. In figure FO-14, transformer T1 is shown connected for 120-volt operation. Through a strapping option on chassis A10 (refer to figure FO-34), the input to transformer T1 can also be connected for 105-, 210-, or 240-volt operation. The output of T1 is rectified and filtered into an unregulated dc voltage by rectifier diodes CR1 and CR2 and filter capacitors C15 and C16. The battery voltage from the power switch is applied to the filter capacitors through fuse AlOAlF1 and diode CR3. Diodes CR1, CR2, and CR3 provide isolation between the ac and dc power sources. Either power source can power the radio set. Floating the battery across the power supply provides automatic backup power in the event of an ac power failure. Through a battery charger connected to the battery charger output (J22-c), the battery can be maintained in a fully charged condition while operating off the ac power line.

4-32. The unregulated de voltage is applied to the regulating dc-dc converter of de-de converter module A5. Through a remote sensed output, the dc-dc con- verter maintains regulated +26 V de across filter capacitor C14 The regulated +26 V de is applied through filters FL1 and FL2 to power amplifier module A8 and through a low-pass filter (L5-C6) to the 22-volt series regulator of voltage regulator module A6. In addition, the +26-V de voltage is applied to the C-7999/GRC-171 to power panel lights and to the power lamp (AlOAlDS1) on the front panel to provide indication that the radio set is turned on.

4-33. Internal to dc-dc converter module A5, +26 V dc is applied to a second dc-dc converter that develops 100, 10, and -17 V dc (-12 and +5 V dc). The 100-V dc output is applied through a low-pass filter (L10- C12) to rf filter module A7. The other two voltages from the dc-dc converter are applied through low-pass filters (L1-C1, L2-C2, L7-C8, and L8-C9)tothe+5.1- and -12-volt series regulators of voltage regulator module A6. Positive 26 V dc from the regulating dc-de converter is applied through a low-pass filter (L4-C4) to the +12-volt series regulator. In addition to +5.1, ±12, and +22 V dc, the voltage regulator module provides zener regulated +14 V dc and a diode developed -0.7 V de. The output voltages from the voltage regulator module are applied to circuits of the receiver- transmitter. The -0.7-V dc voltage is applied to the REMOTE/LOCAL switch. The purpose of this voltage is to compensate for the diode drop of isolation diodes used in the frequency select circuit and in the power on-off circuit.

4-34. The remote on/off input to the regulating de-dc converter is used to turn the radio set on and off. When the remote on/off input is open, the regulating dc-dc converter is on and power supply voltages are applied to turn the radio set on. When the remote on/off input is ground (0 volt applied), the regulating dc-dc converter is off. This causes all power supply voltages to go to zero to turn the radio set off. When the REMOTE/LOCAL switch is in the REMOTE position, the radio set is turned on by setting the C-7999,/ GRC-171 PWR ON,/OFF switch to ON which opens the remote on/off line. When the PWR ON/OFF switch is set to the OFF position, -0.7 V de is applied through diode CR16 of the C-7999/GRC-171. This applies 0 volt to the remote on/off line to turn the radio set off. To turn the radio set on locally when it has been turned off remotely, the REMOTE/LOCAL switch is set to the LOCAL position. This opens the remote on/off line to turn the radio set on. To turn the radio set off locally when it has been turned on remotely, the front panel POWER switch is set to OFF. This removes input voltage from the regulating dc-de converter.

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SECTION II
FUNCTIONAL OPERATION OF ELECTRONIC CIRCUITS

4-35. GENERAL.

4-36. This section provides a detailed circuit description of Radio Set Control C-7999/GRC-171 and of each module of Radio Receiver-TransmitterRT-980/GRC-171. The description of each module includes a functional description that is supported by a block diagram and a detailed description of electronic circuits that is supported by simplified schematic and complete schematic diagrams.

4-37. In this section reference is made to logic 0 and logic 1 voltage levels. A logic 0 voltage level is defined as a voltage between 0 and +0.4 V dc. A logic 1 voltage level is defined as a voltage between +2.4 and +5.5 V dc.

4-38. RADIO SET CONTROL C-7999/GRC-171.

4-39. Refer to the schematic diagram of figure FO-17. The C-7999/GRC-171 contains five thumb-wheel switches (S3 through S7) for remote frequency select and two spst switches (S1 and S2) for remote power on/off and squelch on/off of the receiver-transmitter. It also contains a potentiometer (R1) for control of audio level from the receiver-transmitter and a ready lamp (DS1) that indicates the radio set is tuned and ready for use. When off, the lamp indicates the receiver-transmitter is in the process of tuning or that there has been a circuit malfunction. The panel lights provide illumination for labeling on the front panel of the C-7999/GRC-171.

4-40. The frequency select switches develop bcd frequency select information in accordance with table 4-1. When applied to the 15-frequency select lines to the receiver-transmitter, the bcd frequency select information tunes the radio set to the frequency displayed on the thumb-wheel switches. Diodes CR1 through CR15 provide isolation between the frequency select switches of the C-7999/GRC-171 and the switches of the local frequency select located on the

Table 4-1. Radio Control Frequency Select Coding

MEGAHERTZ

2	2	5.	5	75

100-MHz RADIO CONTROL DIGIT	FREQ SEL LINE 100 MHz
2	0
3	1

0.1-, 1.0-, AND 10-MHz RADIO CONTROL DIGITS	FREQ SEL LINES (MHz)			
	0.1	0.2	0.4	0.8
	1	2	4	8
	10	20	40	80
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1

25-kHz RADIO CONTROL DIGIT	FREQ SEL LINES (kHz)	
	25	50
00	0	0
25	1	0
50	0	1
75	1	1

front panel of the receiver-transmitter. Depending upon the frequency displayed, each switch applies either -0.7-V dc power supply voltage or an open circuit to the cathode of the diodes. When connected to pullup resistors in the d/a servo amplifier module, each frequency select line applies either a logic 0 or logic 1 voltage to the receiver-transmitter.

4-41. The receive signal flow diagram of figure FO-16 shows a typical (10-MHz) frequency select line for the radio set. The choice between local frequency control or remote frequency control is provided by the REMOTE/LOCAL switch (A10A1S3). When the REMOTE/LOCAL switch is in the REMOTE position, the -0.7-V dc power supply voltage is applied to the frequency select switches of the C-7999,/GRC-171. Depending upon the frequency selected, the C-7999/ GRC-171 applies either a logic 0 or logic 1 voltage (note pullup resistor in the d/a servo amplifier module) to the frequency select lines going to the frequency synthesizer module and to the d/a servo amplifier module. When the REMOTE/LOCAL switch is in the LOCAL position, the -0.7-V dc power voltage is applied to the local frequency select switches on the front panel of the receiver-transmitter. Depending upon the frequency selected, the local frequency select applies either the -0.7-V dc power supply voltage or an open circuit to the frequency select lines to the d/a servo amplifier module. Isolation diodes and pullup resistors in the d/a servo amplifier module convert the -0.7-V dc voltage or open circuit into a logic 0 or logic I voltage. respectively, and apply the result to the d/a converter and to the frequency select lines to the frequency synthesizer module.

4-42. D/A SERVO AMPLIFIER MODULE Al.

4-43. Refer to the block diagram of figure FO-4 and schematic diagram of figure FO-18 while reading the following circuit descriptions. Unless otherwise specified, reference designators apply to components of the d/a servo amplifier module Al.

4-44. GENERAL. Refer to figure FO-4. D/a servo amplifier module Al contains the digital-to-analog (d/a) converter and the servo amplifier that controls the servo mechanism in rf filter module A7 to tune the rf filter. The d/a converter changes bcd frequency select information from the radio control into a d/a analog control signal that represents the frequency as selected on the radio control. The servo amplifier receives the d/a analog control signal and compares it to a position feedback signal from the position feedback potentiometer in the rf filter module that represents the tuned frequency of the rf filter. When the two signals differ (frequencies differ), the servo amplifier drives the servo mechanism. to position the rf filter to the desired frequency. The servo amplifier disable circuit prevents the servo mechanism from being driven past its end stops. The servo fault circuit provides a tune-in-progress indi- cation or an indication of invalid circuit conditions.

4-45. LOCAL/REMOTE FREQUENCY SELECT LINES. Refer to figure FO-18. Pullup resistors R1 through R13 located in the d/a servo amplifier module provide termination for the local and remote frequency select lines. The resistors convert an open circuit frequency select line into a logic 1 voltage and a grounded (actually about -0.7 V dc) frequency select line into a logic 0 voltage. Diodes CR1 through CR13 isolate the local (front panel) frequency select switches from the remote (C-7999/ GRC-171) frequency select switches. Isolation diodes for the remote frequency select switches are located in the C-7999/GRC-171. Refer to paragraphs 4-40 and 4-41 for further discussion of frequency select lines.

4-46. DIGITAL-TO-ANALOG CONVERTER. Refer to figure FO-18. The d/a converter consists of four voltage amplifiers (U1A, U2B, U1B, U2A) that amplify the output voltage from a reference voltage amplifier (U3B). The gain and, therefore. the output voltage of each voltage amplifier is varied by connecting resistors (R27 through R32 and R41) to ground through transistor switches (Q1l through Q13) that are turned on by logic 1 voltage of the applied bcd frequency select information. The output voltage from each voltage amplifier is summed together (R45) and amplified (U4B, U4A) to produce the analog voltage to the servo amplifier. The analog voltage varies from about -8 V dc for a radio control frequency of 225 MHz to about +8 V dc for a frequency of 400 MHz. The following describes individual circuits of the d/a converter.

4-47. The 0.1-MHz voltage amplifier (U1A). 1.0-MHz voltage amplifier (U2B), and the 10.0-MHz voltage amplifier (UIB) all function identically. Therefore. only the 0.1-MHz voltage amplifier will be discussed in detail. Resistors R27 through R30 that are connected to the inverting input of the 0.1-MHz voltage amplifier vary the amplifier gain when they are connected to ground through transistors Q1, Q2, Q3, and Q4. The transistors turn on in accordance with 0.1-MHz bcd frequency select information applied to the d/a servo amplifier module. The transistors are connected in the reverse beta mode so that their collector-to-emitter voltage is approximately 0 V dc when turned on by a logic 1 applied to their base. The reference voltage amplifier (U3B) amplifies +12-V and -12-V dc power supply voltages to produce a reference voltage (approximately +3.56 V de) that is applied to the non-inverting input of the 0.1-MHz voltage amplifier. As the radio control 0.1-MHz frequency digit (bcd frequency select information) varies from 0 (0000) to 9 (1001), the 0.1-MHz voltage amplifier amplifies the reference voltage to produce an output voltage that varies from about 3.56 to about 7.60 volts in approximately 0.447-volt steps

per 0.1-MHz digit. In a like manner, the output voltages from the 1.0-MHz voltage amplifier (U2B) and the 10.0-MHz voltage amplifier (U1B) vary from about 3.56 to about 7.60 volts as the corresponding radio control frequency is changed from 0 to 9.

4-48. The 200/300-MHz voltage amplifier (U2A) amplifies the output voltage from the reference voltage amplifier. Resistor R41 varies the amplifier gain when it is connected to ground through transistor Q13. When the 100-MHz frequency select line is changed from logic 0 (200 MHz) to logic 1 (300 MHz). transistor Q13 turns from off to on to ground resistor R41. This causes the output voltage from the 200/300-MHz voltage amplifier to vary from about 3.56 to about 8.05 V dc. Adjustable resistor R42 varies the output voltage to compensate for the dc offset of U2A.

4-49. The summing network (R45) and the voltage swing amplifier (U4B) together form a summing amplifier that sums and amplifies the output voltages from the four voltage amplifiers (U1A, U2B, U1B, and U2A) and the reference voltage amplifier (U3B). When summed together, the five input voltages produce an output voltage from the voltage swing amplifier that varies from about +2.07 volts for a frequency of 225.0 MHz to about -5.75 volts for a frequency of 399.9 MHz in approximately 4.47-millivolt steps per 100 kHz. Diode CR15 provides temperature compensation for the d/a converter.

4-50. The dc centering amplifier (U4A) sums and amplifies the voltage swing amplifier (U4B) output voltage, the reference voltage amplifier output voltage, and the +12and -12-V dc power supply voltages. The +12and -12-V dc power supply voltages are applied to the dc centering amplifier to compensate for changes in the reference voltages. When summed together. the four input voltages produce an output voltage from the dc centering amplifier that varies from about -8 V dc for a frequency of 225.0 MHz to about +7.995 V dc for a frequency of 399.9 MHz in approximately 9-millivolt steps per 100 kHz. To obtain this voltage range versus frequency, variable resistor R47 allows adjustment for a total output voltage swing of about 15.995 V dc when the frequency is changed from 225.0 to 399.9 MHz, and variable resistor R50 allows adjustment to center the output voltage at about -1.15 V dc for a frequency of 299.9 MHz. The analog output voltage from the dc centering amplifier is applied to the servo amplifier. Each 9millivolt step between -8 and +8 V dc represents a specific radio control frequency.

4-51. SERVO AMPLIFIER. Refer to figure FO-18. The servo potentiometer amplifier (U6) amplifies the position feedback signal by a voltage gain of about 2. Variable resistor R73 allows adjustment of the gain of U6. Potentiometer R74 allows adjustment for zero output voltage from U6 when the input voltage is zero. Resistor R70 combines the position feedback signal with the d/a analog signal in such a manner as to compensate for nonlinear tracking characteristics of the rf filter.

4-52. The d/a servo potentiometer comparator (U7) develops the servo error signal by comparing the amplified position feedback signal with the d/a converter analog signal. Diodes CR19 and CR20 limit the input to U7 to approximately $\pm$0.7 Vdc. Capacitor C12 in parallel with resistor R77 provides lag for servo amplifier stability.

4-53. The servo error amplifier (US) amplifies the servo error signal from the d/a servo potentiometer comparator (U7) to develop either a positive or negative output voltage to the servo motor drive circuits (Q15 through Q23). When the output voltage is positive, the down frequency servo drive circuit (Q15, Q22, Q18) applies voltage to the servo motor to position the rf filter down in frequency. When the output voltage from U8 is negative, the up frequency servo drive circuit (Q17, Q16, Q23, Q20) applies voltage to the servo motor to position the rf filter up in frequency. Servo motor voltage applied through resistors R84 and R86 provides negative feedback to U8 to control the gain of the overall servo amplifier. For large servo error signals, the servo amplifier applies about 13 V dc to the servo motor. As the servo error signal approaches the null, the servo amplifier reduces the voltage applied to the servo motor to stop the servo motor and prevent overshoot when the null is reached.

4-54. Rf filter tuning occurs as follows. The rf filter position with respect to frequency is calibrated so that the output voltage from the position feedback potentiometer (A7R20) when amplified by a factor of 2 (U6 output) tracks (equals) the output voltage from the d/a converter (U4A output) for each 100-kHz frequency step between 225.0 and 399.9 MHz. Therefore, to tune the rf filter, it is only necessary to drive the servo motor which drives the position feedback potentiometer in the direction that equalizes the two voltages at the input to d/a servo potentiometer comparator U7. When the voltages are equal, the servo error signal nulls to stop the servo motor. When this occurs. the rf filter is tuned to the same frequency as the radio control frequency.

4-55. When the radio control is set to a higher frequency the d/a analog voltage at the non-inverting input of U7 becomes positive with respect to the position feedback voltage at the inverting input of U7. This results in a positive servo error signal to the inverting input of the servo error amplifier, U8. The resulting negative output voltage from U8 reverse biases transistors Q15 of the down frequency servo drive circuit (Q15, Q22, Q18) and forward biases transistor Q17 of the up frequency servo drive circuit (Q17, Q16, Q23, Q20). When Q17 is forward biased, transistors

Q17, Q16, and Q23 amplify the negative output voltage from U8 to control base drive to transistor Q20. Transistor Q23 also provides base drive through resistor R92 to the up frequency enable transistor, Q19, causing it to turn on. Transistor Q20, when turned on, provides' voltage to the servo motor (positive voltage to P1-22). Transistor Q19 provides a ground return for the servo motor (P1-Z). Servo amplifier gain maintains approximately 13 V dc across the servo motor to drive the rf filter toward the higher frequency. As the new frequency is approached, the output of U8 goes toward 0 volt which in turn reduces the base drive to transistors Q20 and Q19. At the null, transistors Q20 and Q19 turn off to stop the rf filter at the new frequency.

4-56. When the radio control is set to a lower frequency, the d/a analog voltage at the non-inverting input of U7 becomes negative with respect to the position feedback voltage at the inverting input of U7. This results in a negative servo error signal to the inverting input of the servo error amplifier, U8. The resulting positive output voltage from U8 reverse biases transistors Q17 of the up frequency servo drive circuit (Q17, Q16, Q23, Q20) and forward biases transistor Q15 of the down frequency servo drive circuit (Q15. Q22, Q18). When Q15 is forward biased, transistors Q15 and Q22 amplify the positive output voltage from U8 to control base drive to transistor Q18. Transistor Q22 also provides base drive through resistor R101 to the down frequency enable transistor, Q21, causing it to turn on. Transistor Q18, when turned on, provides voltage to the servo motor (positive voltage to P1-Z). Transistor Q21 provides a ground return for the servo motor (P1-22). The applied voltage to the servo motor drives the rf filter toward the lower frequency. As the new frequency is approached, the output of U8 goes toward 0 volt which in turn reduces the base drive to transistors Q18 and Q21. At the null, transistors Q18 and Q21 turn off to stop the rf filter at the new frequency.

4-57. SERVO AMPLIFIERDISABLE. The servo amplifier disable circuit (U9A, U9B, Q24, Q25 of figure FO-18) functions as a double ended limit detector to turn off the servo motor if it tries to run past the end stops of the servo mechanism. Resistor R106 of voltage divider R108-R106-R105 is test selected to set the upper limit voltage applied to the inverting input of U9A (approximately +4.1 V dc). Resistor R107 of voltage divider R109-R107-R68 is test selected to set the lower limit voltage applied to the inverting input of U9B (approximately -4.1 V dc). The position feedback signal is applied to the non-inverting inputs of both U9A and U9B. Also, the d/a analog signal is applied through resistor R70 to the non-inverting inputs. If the resulting voltage from these two signals is between the upper and lower limit voltage, the output of U9A will be negative to turn off transistor Q24 and the output of U9B will be positive to turn off transistor Q25. If the resulting voltage exceeds the upper limit voltage. which would be the case if the d/a analog signal tries to drive the rf filter above 400 MHz, or if the rf filter actually is driven above 400 MHz, the output of U9A goes positive to turn on transistor Q24. When on, Q24 shunts to ground base drive to transistor Q19. This turns Q19 off which opens the motor circuit to prevent the rf filter from being driven any higher in frequency. In a similar manner, if the resulting voltage exceeds the lower limit voltage, which would be the case if the d/a analog signal tries to drive the rf filter below 225 MHz or if the rf filter is actually driven below 225 MHz, the output of U9B goes negative to turn on transistor Q25. When on, Q25 shunts to ground base drive to transistor Q21. This turns Q21 off which opens the motor circuit to prevent the rf filter from being driven any lower in frequency. Through this circuit action, the rf filter is prevented from being driven above 400 MHz (upper end stop) or below 225 MHz (lower end stop).

4-58. SERVO FAULT AMPLIFIER. The servo fault amplifier (Q14 of figure FO-18) receives inputs from the servo amplifier through diodes CR17 and CR18 and from the 200- to 219-MHz decoder (U5) through diode CR32 and provides at its output a dual-purpose rf filter fault signal. The fault signal goes to logic 0 to indicate an invalid circuit condition if the radio control frequency is set below 220 MHz or if a servo malfunction causes voltage to be applied to the servo motor at times other than normal tuning. For normal servo operation, the rf filter fault signal goes to logic 0 to provide a tune-in-progress indication whenever the rf filter is in the process of being tuned.

4-59. The circuit operates as follows. Whenever the radio control frequency is set below 220 MHz, all inputs to the 200- to 219-MHz decoder, U5, become logic 0. This results in a logic 1 output voltage that is applied through diode CR32 to the base of servo fault amplifier transistor Q14 causing it to turn on. When Q14 turns on, the rf filter fault output (P1-3) goes to logic 0 to indicate an invalid circuit condition. If the radio control frequency is set at 220 MHz or above, the rf filter fault output goes to logic 0 whenever the voltage applied to the servo motor exceeds a threshold (about 7.5 V dc) established through voltage divider action of diode CR17 or CR18, zener diode VR1, and resistors R60, R59, and R61. Servo motor voltages greater than the threshold develop sufficient voltage across R61 to forward bias transistor Q14 and turn it on. Capacitor C10 and resistors R59 and R61 form a slow release circuit to hold the filter fault output at logic 0 f or at least 10 milliseconds after the servo motor voltage decreases below the threshold.

4-60. FREQUENCY SYNTHESIZER MODULE A2.

4-61. GENERAL. Frequency synthesizer module A2 utilizes a 2-modulus prescaler form of digital phase-lock loop (p11) to generate the transmit frequency to

power amplifier module A8 and to receive injection frequency to receiver rf module A3. Refer to figure 4-1. The p11 frequency synthesizer operates as follows: The variable divider divides the output frequency (F_O) by N and applies the resulting frequency (F_V) to the phase detector. The phase detector compares F_V in both frequency and phase to the reference frequency (F_R). The frequency or phase difference between the two signals produces an error signal which is filtered and applied to the voltage-controlled oscillator (vco). The vco changes frequency until F_V equals F_R. Phase lock occurs when F_V equals F_R and their phase difference is constant, The system equation is $F_O = F_R \times N$.

4-62. The variable divider functions as a counter where one output pulse is generated for every N input pulse. The variable divider consists of a divide-by-2 fixed prescaler, a divide-by-N_p ($\div N_p$) programmable counter, a divide-by-A ($\div$A) programmable counter, and a 2-modulus prescaler. The $\div$A programmable counter is programmed (preset to a certain count) by the three least significant digits of the radio control while the -Np programmable counter is programmed by the three most significant digits of the radio control and the transmit/receive key line. The 2-modulus prescaler is controlled by the $\div$A programmable counter to divide by either 40 or 41.

4-63. In the 2-modulus prescaling technique, frequency division occurs as follows: At the beginning of a cycle, the $\div$A programmable counter is preset to a count of A and the $\div N_p$ programmable counter to a count of Np as determined by the radio control. (For the example frequency given in figure 4-1, A is 35 and N_p is 325.) The 2-modulus prescaler divides the output of the fixed prescaler by 41 to produce one output pulse for every 41 input pulses (82 cycles of FO). The output pulse causes the preset count of the -A programmable counter and +Np program- mable counter to decrement by 1. (These counters count down from the preset count to zero.) This process continues until the $\div$A programmable counter is decremented to zero. When the $\div$A programmable counter reaches zero count, it feeds back a control signal to the 2-modulus prescaler to change its division ratio from 41 to 40. To this point, the total number of pulses (cycles of F_O) counted is 2 x 41 x A. Since the $\div$Np programmable counter decrements by the same number of counts as the $\div$A programmable counter, the count remaining in the -. Np programmable counter is $N_p \div$A. As the cycle continues, the output of the 2-moduluspresca ler continues to decrement the $\div N_p$ programmable counter except now it only requires 40 input pulses to produce one output pulse. When the $\div N_p$ programmable counter is decremented to zero, it produces one output pulse to the phase detector and at the same time resets the $\div N_p$ programmable counter and $\div$A programmable counter to the preset count of Np and A, respectively.

to start a new cycle. For the complete cycle, the number of pulses counted by the variable divider is 2 [(41)(A) + 40 (N_p - A)]. (In the example frequency of figure 4-1, the number of pulses counted is 2 [(41)(35)- 40(325-35)] or 26.070.) The total number of pulses counted is the division ratio (N) of the variable divider. The system equation for the phase- lock loop is, therefore, given by the following equation:

$$F_O = (F_R)(2)\,[41\,(A) + 40\,(N_p - A)]$$

Where:

F_R = reference frequency

A = preset count set into $\div$A programmable counter

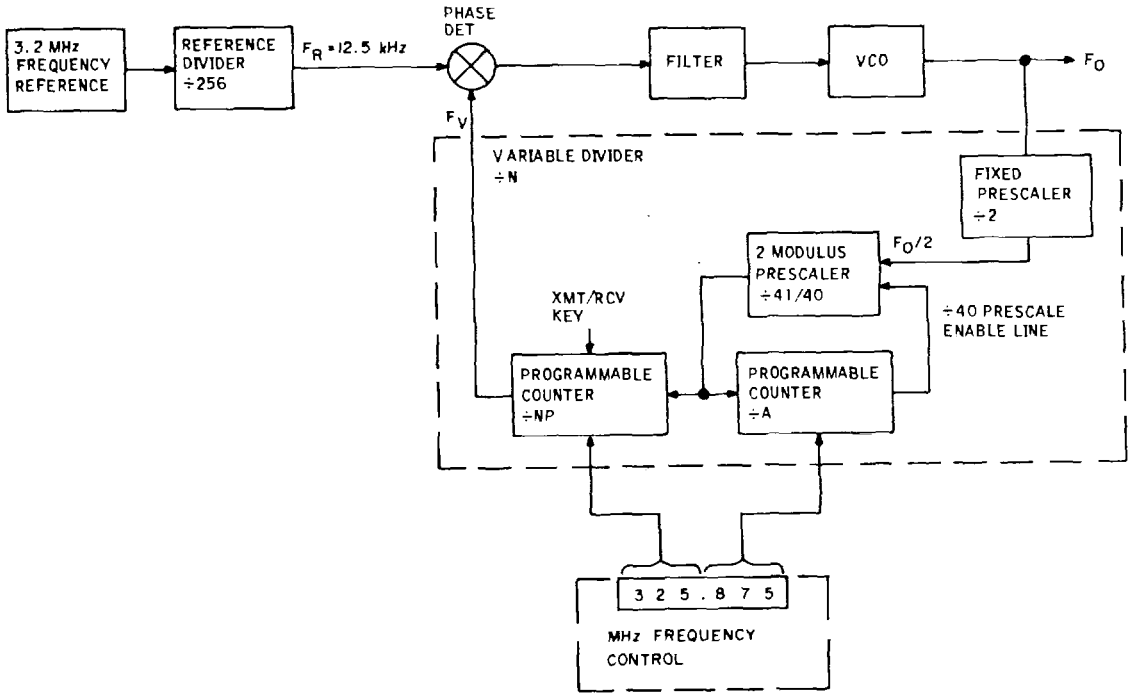
N_p = preset count set into $\div N_p$ programmable counter

4-64. When operating in the receive mode, the transmit/receive key line causes the division ratio of the $\div N_p$ programmable counter to decrease by 30. This causes a 30-MHz decrease in the fre- quency synthesizer output frequency. When mixed with the received signal, the difference results in the 30-MHz if frequency.

4-65. The condition for phase lock occurs when the phase difference between the variable divider output and frequency reference output becomes constant at a value necessary to produce a vco frequency that when divided by N produces 12.5 kHz at the phase detector. The output frequency of the variable divider locks onto and tracks the phase of the reference frequency. The phase difference between the variable divider output and the reference frequency produces a correc- tion voltage at the input to the vco. The level of this correction voltage is such that it will pull the vco frequency in a direction that will cause the variable divider output to phase-track the reference frequency. Thus, for each setting of the radio control, a digital code presets the variable count to an integral number (N) representing a desired out put frequency. For each desired output frequency there is a corresponding unique phase difference and tuning voltage to the vco. At each tuned condition the variable divider output is phase locked to the reference frequency and the two frequencies are equal to 12.5 kHz. The output fre- quency (vco frequency) is therefore equal to the following:

$$\text{vco frequency} = N \times 12.5\ \text{kHz}$$

4-66. Refer to figure FO-5 for a block diagram of frequency synthesizer module A2. The low-band,



NOTES:

1. SYSTEM EQUATION:
   FOR PHASE LOCKED LOOP,
   $F_V = F_R = F_O / N$
   $F_O = F_R \cdot N$
   WHERE $N = 2\left[41 \cdot A + 40(N_P - A)\right]$
   $F_O = F_R \cdot 2\left[41 \cdot A + 40(N_P - A)\right]$

2. PROGRAMMABLE COUNTER ÷A:
   PRESET COUNT A VARIES FROM 0 TO 39 AND INCREMENTS BY 1 FOR EACH 25 kHz INCREASE IN FREQUENCY CONTROL

FREQ (MHz)	A
XXX.000	0
XXX.025	1
XXX.050	2
XXX.075	3
XXX.100	4
•	•
•	•
•	•
XXX.875	35
•	•
•	•
XXX.950	38
XXX.975	39

3. PROGRAMMABLE COUNTER, ÷N_P:
   PRESET COUNT N_P VARIES FROM 225 TO 399 FOR TRANSMIT MODE AND FROM 195 TO 369 FOR RECEIVE MODE (30 MHz IF FREQUENCY) AND INCREMENTS BY 1 FOR EACH 1 MHz INCREASE IN FREQUENCY CONTROL.

FREQ (MHz)	N_P XMT MODE	N_P -30 RCV MODE
225.XXX	225	195
226.XXX	226	196
•	•	•
•	•	•
•	•	•
325.XXX	325	295
•	•	•
•	•	•
•	•	•
398.XXX	398	368
399.XXX	399	369

4. FOR EXAMPLE FREQUENCY OF 325.875 MHz,
   $F_O = 12.5\ kHz \cdot 2\left[41 \cdot 35 + 40(325 - 35)\right]$
   $F_O = 325.875$ MHz (XMT MODE)
   FOR RECEIVE MODE;
   $F_O = 12.5\ kHz \cdot 2\left[41 \cdot 35 + 40(325 - 30 - 35)\right]$
   $F_O = 295.875$ MHz

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Figure 4-1. Phase-Locked Loop Frequency Synthesis by 2-Modulus Prescaling

midband, or high-band vco generates the synthesizer output signal which appears at the transmit rf output or receive injection output. The band decoder processes 10- and 100-MHz frequency select informa- tion from the radio control and transmitter key line (key 1) information to enable one of the three voltage- controlled oscillators in accordance with table 4-2. The power splitter couples the vco signal to the synthesizer output and to the variable divider input and provides isolation between the two paths. Rf amplifiers amplify the vco signal to the proper level for receiver injection and transmitter excitation. Key 2 controls the transmit/receive switch to select either the receive injection output during receive mode or the transmit rf output during transmit mode. The regenerative divider, 2-modulus prescaler, $\div A$ programmable counter, and $\div N_p$ programmable counter form the variable divider which divides (as described previously) the output of the power splitter by N to give 12.5 kHz at the frequency/phase detector when phase locked. The reference divider divides the output of the 3.2-MHz frequency reference by 256 to provide a 12.5-kHz reference signal at the reference input of the frequency/phase detector. The frequency/ phase detector compares the two signals and generates an asymmetrical output waveform whose duty cycle is proportional to the phase difference between the two signals. The low-pass filter filters the waveform into a dc tuning voltage that is proportional to the duty cycle. The tuning voltage drives the vco to the proper frequency. In the variable divider, 30-MHz decode and transmit/receive control logic decreases the division ratio by 30 whenever the transmitter is un-keyed to decrease the synthesizer output frequency (receive injection output) by 30 MHz. The lock monitor compares the frequency reference to the variable divider output to provide a pll fault logic signal when- ever the synthesizer is not phase locked.

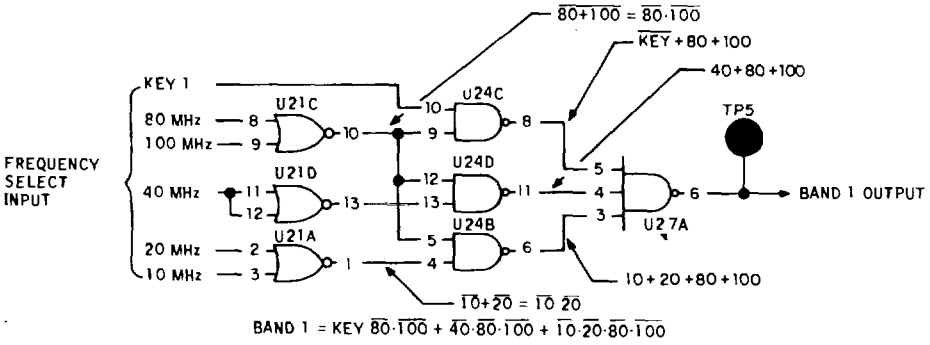
4-67. The following details operation of individual functions of the synthesizer. Unless otherwise specified, reference designators apply to components of frequency synthesizer module A2.

4-68. BAND DECODERS. The synthesizer uses NAND and NOR gate logic to decode transmitter key line information and 10-, 20-, 40-, 80-, and 100-MHz radio control frequency select information into frequency band information. The low-band decoder (figures FO-19 and 4-2) provides a logic 1 output voltage through resistor A2A7R18 to enable the low-band vco, A2A1, whenever the radio control is set below 250 MHz in transmit mode or below 280 MHz in receive mode. The high-band decoder (figures FO-19 and 4-3) provides a logic 1 output voltage through resistor A2A7R20 to enable the high-band vco, A2A3, whenever the radio control is set to 320 MHz or above in transmit mode or to 350 MHz or above in receive mode. The midband decoder (NOR gate A2A7U21B of figure FO-19) decodes the outputs of the low- and high-band decoders to provide a logic 1 voltage through resistor A2A7R19 to enable the midband vco, A2A2. The mid- band decoder output is only logic 1 when the low- and high-band decoder outputs are logic 0. This occurs when the radio control frequency is set between 250 and 319.975 MHz for transmit mode and between 280 and 349.975 MHz for receive mode. Truth tables for the low-band decoder and high-band decoder are given in figures 4-2 and 4-3 respectively.

4-69. VOLTAGE-CONTROLLED OSCILLATORS. The low-band, midband, and high-band voltage-controlled oscillators, A2A1, A2A2. and A2A3 (figure FO-19 and figure 4-4) are identical except for the inductance value of L1 and capacitance value of C4. These components allow the oscillators to be adjusted to cover the three different frequency ranges of the

Table 4-2. VCO and Radio Control Frequency Versus VCO Band

ENABLED VCO	RRADIO CONTROL FREQUENCY (MHz)		VCO FREQUENCY (MHz)	
	XMT MODE	RCV MODE	XMT MODE	RCV MODE
LOW-BAND	225.000 thru 249.975	225.000 thru 279.975	225.000 thru 249.975	195.000 thru 249.975
MIDBAND	250.000 thru 319.975	280.000 thru 349.975	250.000 thru 319.975	250.000 thru 349.975
HIGH-BAND	320.000 thru 399.975	350.000 thru 399.975	320.000 thru 399.975	320.000 thru 369.975



A. SIMPLIFIED LOGIC DIAGRAM.

RADIO CONTROL FREQUENCY (MHz)	FREQ SELECT INPUTS (MHz)					BAND 1 OUTPUT	
						XMT	RCV
	10	20	40	80	100	KEY 1=LO	KEY 1=L1
225.000	LO	L1	LO	LO	LO	L1	L1
230.000	L1	L1	LO	LO	LO	L1	L1
249.975	LO	LO	L1	LO	LO	L1	L1
250.000	L1	LO	L1	LO	LO	LO	L1
260.000	LO	L1	L1	LO	LO	LO	L1
279.975	L1	L1	L1	LO	LO	LO	L1
280.000	LO	LO	LO	L1	LO	LO	LO
290.000	L1	LO	LO	L1	LO	LO	LO
300.000	LO	LO	LO	LO	L1	LO	LO
310.000	*	*	*	*	L1	LO	LO
↓	↓	↓	↓	↓	↓	↓	↓
399.975	*	*	*	*	L1	LO	LO

B. TRUTH TABLE

NOTES:

1. EQUATIONS GIVEN IN SIMPLIFIED LOGIC DIAGRAM ARE BOOLEAN EXPRESSIONS.
2. LOGIC LEVELS
   LO +0.4 V DC MAX
   L1 +2.0 TO +5.5 V DC
3. * INDICATES DON'T CARE.

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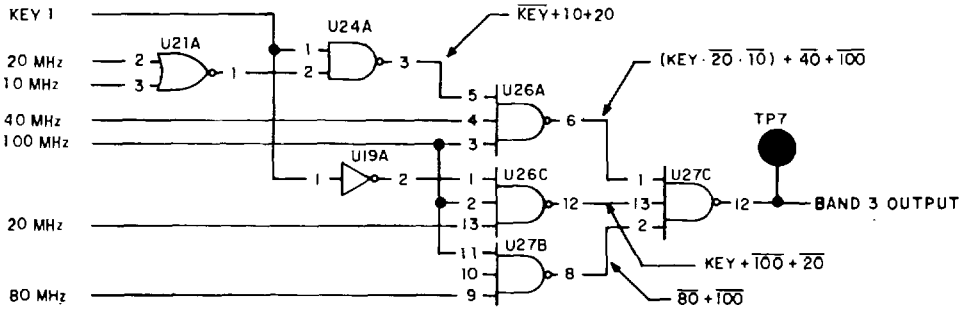
Figure 4-2. Low-Band Decoder, Simplified Logic Diagram and Truth Table



BAND 3 = $\overline{KEY}$·40·100 + 10·40·100 + 20·40·100 + $\overline{KEY}$·20·100 + 80·100

A. SIMPLIFIED LOGIC DIAGRAM

RADIO CONTROL FREQUENCY (MHz)	FREQ SELECT INPUT (MHz)					BAND 3 OUTPUT	
	10	20	40	80	100	XMT KEY=LO	RCV KEY=L1
225.000	*	*	*	*	LO	LO	LO
↓	↓	↓	↓	↓	↓	↓	↓
299.975	*	*	*	*	LO	LO	LO
300.000	LO	LO	LO	LO	L1	LO	LO
319.975	L1	LO	LO	LO		LO	LO
320.000	LO	L1	LO	LO		L1	LO
330.000	L1	L1	LO	LO		L1	LO
349.975	LO	LO	L1	LO		L1	LO
350.000	L1	LO	L1	LO		L1	L1
360.000	LO	L1	L1	LO		L1	L1
370.000	L1	L1	L1	LO		L1	L1
380.000	LO	LO	LO	L1		L1	L1
399.975	L1	LO	LO	L1	L1	L1	L1

B. TRUTH TABLE

NOTES:

1. EQUATIONS GIVEN IN SIMPLIFIED LOGIC DIAGRAM ARE BOOLEAN EXPRESSIONS.
2. LOGIC LEVELS
   LO +0.4 V DC MAX
   L1 +2.0 TO +5.5 V DC
3. * INDICATES DON'T CARE.

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Figure 4-3. High-Band Decoder, Simplified Logic Diagram and Truth Table

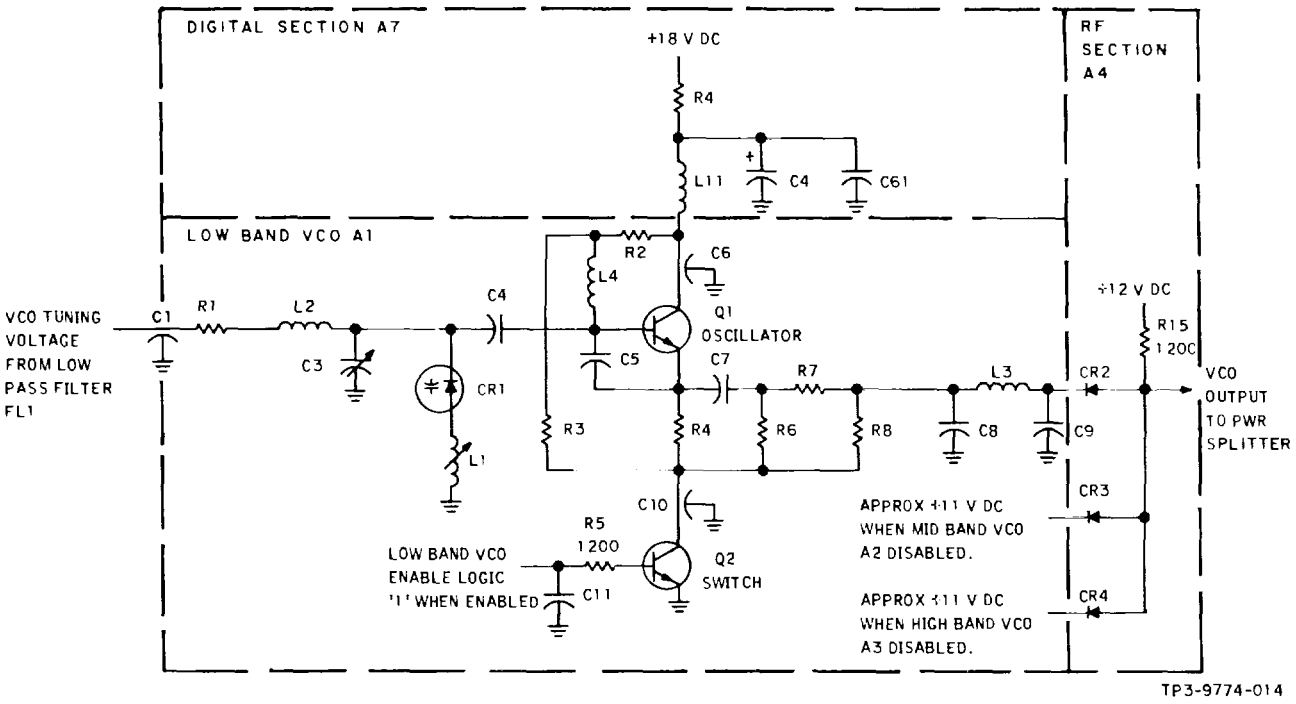

Figure 4-4. Voltage-Controlled Oscillator . Simplified Schematic Diagram

three bands. The only other difference is that the low-band vco has a low-pass filter (A2A1L3, C8, and C9) at its output to filter second harmonic frequencies which fall below the 400-MHz upper frequency limit of the synthesizer. Each vco is a sealed, non repairable, nonadjustable unit. However, to understand circuit operation the low-band vco will be discussed.

4-70. Radio control frequencies that fall in the low- band range cause the low-band decoder to apply a logic 1 voltage through resistors A2A7R18 and A2A1R5 to the base of transistor switch A2A1Q2 turning it on. When on, A2A1Q2 applies a ground to the voltage- controlled oscillator circuit exciting A2A1Q1 into oscillation. At the same time A2A1Q2 provides a current path to ground from the +12-V dc supply through A2A4R15, A2A4CR2, A2A1L3, and resistive pad A2A1R6-R7-R8. This forward biases diode A2A4CR2 to enable the low-band vco output and at the same time reverse biases diodes A2A4CR3 and A2A4CR4 to open the midband and high-band outputs. In the vco circuit, voltage developed across resistor A2A1R3 of voltage divider A2A1R2-A2AlR3 and applied through choke A2A1L4 sets the bias point of A2A1Q1. The tuned circuit, composed of capacitor A2A1C3, varactor A2AlCRl, and inductor A2A1L1 in conjunction with capacitors A2A1C4 and A2A1C5, determines the oscillating frequency of the vco. Tuning voltage from low-pass filter A2A5FL1 applied through resistor A2A1R1 and choke A2A1L2 to varactor A2AlCR1 causes the frequency of the vco to vary. As the tuning voltage increases, the capacitance of A2A1CR1 decreases causing the frequency to increase. By adjusting A2A1L1 and A2A1C3, the range of the vco frequency is set so varactor A2A1CR1 controls the frequency from below the lowest frequency (195 MHz) to above the highest frequency (250 MHz) of the low band. The vco output signal is developed across emitter resistor A2A1R4 and fed through coupling capacitor A2A1C7. resistive pad A2A1R6-R7-R8, low-pass filter A2A1C8-L3-C9, and diode A2A4CR2 to the vco output. Resistor values of A2A1R6, R7, and R8 are test selected to set the output of the vco to about 800 millivolts which, in turn, sets the synthesizer transmit rf and receive injection output levels at 14 ±2 dB mW when loaded into 50 ohms.

4-71. Decoupling network A2A7R4-C61-C4-L1 de-couples the three voltage-controlled oscillators from the +18-V dc supply voltage. This prevents the 3.2- MHz tcxo frequency from interfering with the vco frequency.

4-72. POWER SPLITTER. Capacitor A2A4C11 (figure FO-19, sheet 3) couples the output of the selected vco to the power splitter which separates the vco signal into two signal paths. One signal path feeds output amplifier circuit A2A6 through -12-dB pad A2A4R12-R13-R14. The other signal path feeds the regenerative divider circuit of the variable divider through -15-dB pad A2A4R11-A2A7R21-R22-R23. Besides separating the vco signal, the power splitter provides isolation between the half frequency of the regenerative divider and vco signal being fed to power amplifier circuit A2A6.

4-73. OUTPUT AMPLIFIER A2A6. Reference designators apply to output amplifier A2A6, Output amplifier A2A6 (figure FO-19) consists of a 3-stage rf amplifier (rf amplifiers Q2, Q4, andQ6 and associated bias amplifiers Q1, Q3, and Q5) followed by a diode type (CR2 and CR3) transmit/receive switch. In the 3-stage rf amplifier, bias amplifiers Q1, Q3, and Q5 set the collector currents of Q2, Q4, and Q6 respectively. Since all bias amplifiers function the same, only bias amplifier Q1 will be discussed. The voltage divider R2-R3 sets the base voltage of Q1 at about 9.4 V dc which fixes the emitter voltage at about 10.0 V dc. The resulting voltage drop (about 2 V dc) across R4 sets the collector current of Q1 at approximately 29 milliamperes. For the other two stages, resistor R8 sets the collector current of Q4 at approximately 29 milliamperes, and resistor R12 sets the collector current of Q6 at approximately 51 milliamperes. In the rf path, variable capacitor C1, variable capacitor C5 in series with inductor L3, and variable capacitor C8 in parallel with inductor L4 allow adjustment of the 3-stage rf amplifier for maximum flatness over the frequency range of the synthesizer. In the base circuit of Q2. capacitor C23 compensates for lead inductance of Q2. In the t12-V dc circuit, inductors L10, L5, andL2and capacitors C11, C7, and C4 form a decoupling network to decouple the rf amplifier from the +12-V dc line. At the output of rf amplifier Q6, the signal is coupled through C10 to the transmit/receive switch and is loosely coupled through capacitor C12 to detector diode CR1. The dc voltage developed across CR1 is brought out to the pll output (testpoint 4 on chassis A10) to give an indication as to the level of rf at the input to the transmit/receive switch.

4-74. TRANSMIT/RECEIVE SWITCH. Reference designators apply to A2A6. The transmit/receive switch (figures FO-19 and 4-5) enables either the transmit rf output of the synthesizer or the receive injection output. In transmit mode, a logic 0 key 2

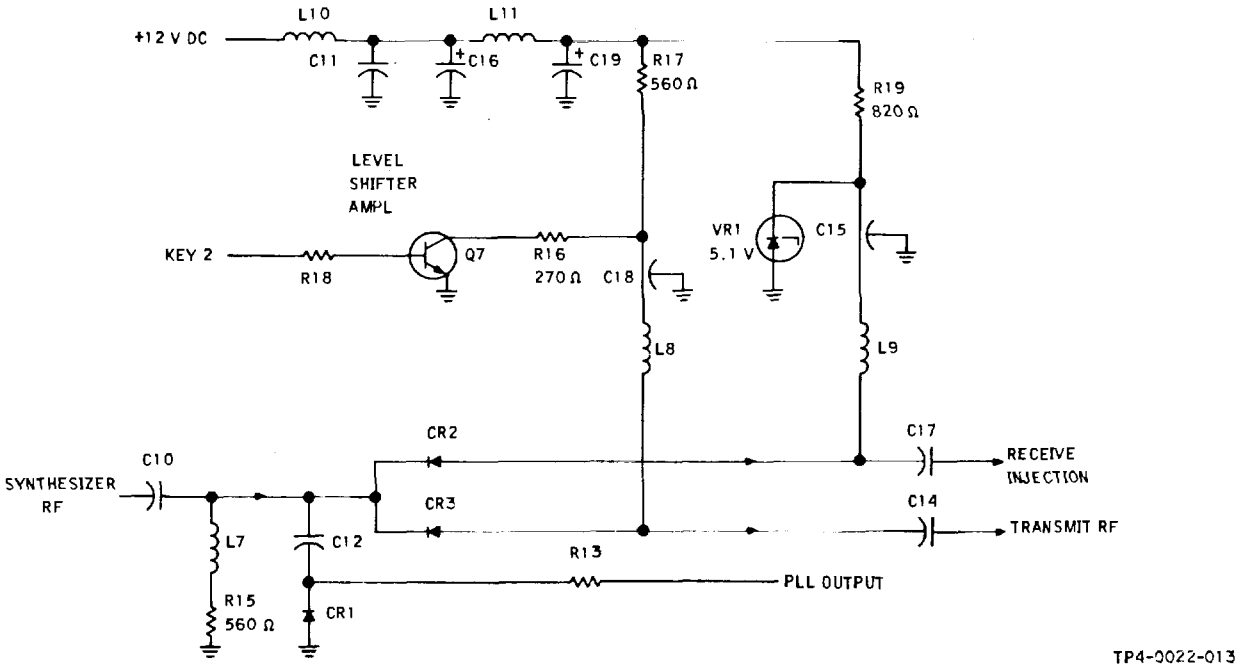

Figure 4-5. Frequency Synthesizer Transmit-Receive Switch, Simplified Schematic Diagram

signal turns level shifter amplifier Q7 off. With Q7 off, +12 V dc applied through L10, L11, R17, C18, L8, CR3, L7, and R15 to ground develops approximately 6 V dc at the cathode of diodes CR2 and CR3. Zener diode VR1 applies +5.1 V dc through C15 and L9 to the anode of diode CR2 causing CR2 to be back biased. This blocks the synthesizer rf signal from being applied to the receive injection input to receiver rf module A3. Forward-biased diode CR3 allows the synthesizer transmit rf signal to be applied through C14 to the transmit rf input of power amplifier module A8.

4-75. In receive mode, a logic 1 key 2 signal turns level shifter amplifier Q7 on. With Q7 on, +12 V de applied through L10, L11, R17, R16, and Q7 to ground develops approximately 4 V dc at the junction of R16, R17, C18, and L8. This voltage is applied to the anode of diode CR3 through C18 and L8. Zener diode VR1 applies +5.1 V dc through C15, L9, and CR2 to the cathode of diode CR3. This back-biases diode CR3 blocking the synthesizer rf signal from being applied to the transmit rf input of power amplifier module A8. Forward-biased diode CR2 allows the synthesizer receive injection signal to be applied through C17 to the receive injection input of receiver rf module A3.

4-76. When switching from receive mode to transmit mode, current flows through CR3 to back-bais CR2. This results in some overlap where both diodes are on at the same time (make before break). This prevents switching transients from being reflected back through the power amplifier to affect vco frequency which could result if the transmit/receive switch were to open while switching (break before make). In a similar manner, current flows through CR2 to back-bias CR3 when switching from transmit to receive mode.

4-77. At the receiver injection output, capacitor C17 and inductor L9 form a high-pass filter to attenuate 30-MHz spurious (if frequency) that may be present in the receiver injection signal.

4-78. VARIABLE DIVIDER. Refer to figure FO-1l. The variable divider consists of the regenerative divider, 2-modulus prescaler, $\div$A programmable counter, $\div N_p$ programmable counter, and various control logic. The simplified schematic diagram of the complete variable divider presented by figure FO-11 includes a timing diagram for radio control frequency of 334.350 MHz. Encircled letters appearing on the variable divider simplified schematic diagram make reference to waveforms shown on the timing diagram. The waveforms pictured are theoretical and may not appear as square waves when measured with a wide-band oscilloscope. In the text, reference to waveforms will be by letter, ie, waveform A, waveform B, waveform AB, presetpulse G, etc.

4-79. The variable divider functions by counting N input cycles of the vco frequency to produce one output pulse to the frequency/phase detector. For the example frequency of 334.350 MHz, N would be 26,748 to give 12.5 kHz at the frequency/phase detector. Dividing 26,748 by the regenerative divider fixed division ratio of 2, leaves a count of 13,374 to be counted by the remaining circuits of the variable divider. To accomplish this, at the beginning of each count period. preset pulses (waveforms G and W) preset the .+A programmable counter to a count of 14 and the +Np programmable counter to a count of 334. The 25-, 50-, and 100-kHz frequency select information from the radio control (350 kHz for the example frequency) is preset into the . A program- mable counter to set its count at 14. It therefore requires 14 input pulses (waveform) to get one out- put pulse (waveform X). The 1-, 10-. and 100-MHz frequency select information (334 MHz for the example frequency) is preset into the $\div N_P$ programmable counter to set its count to 334. For this counter, it requires 334 input pulses (waveform Z) to get one output pulse (waveform G). At the beginning of a count period just following the preset pulses, the 2-modulus prescaler divides by 41 to produce one output pulse (waveform F) for every input pulse (waveform A). The output pulse is fed to both the $\div N_p$ programmable counter (waveform Z) and $\div$A programmable counter (waveform I). The $\div$A programmable counter counts 14 of these pulses after which time it feeds back a logic control signal (waveform H) to the 2-modulus prescaler to change its division ratio to 40. For the remainder of the period, the 2-modulus prescaler divides by 40. As a result of this, for the first 14 pulses counted by the $\div N_p$ programmable counter, the 2-modulus prescaler divides by 41. For the remaining 320 pulses counted by the $\div$N programmable counter. the 2-modulus prescaler divides by 40. The total number of input pulses to the 2-modulus prescaler would therefore be 14 (41) + 320 (40) or 13,374 which is the desired count following the regenerative divider. The output pulses (waveforms G and W) fed to the frequency/ phase detector are also fed back as preset pulses to preset the programmable counter to start a new count period.

4-80. Regenerative Divider. Reference designators apply to digital section A2A7. To divide the vco frequency by 2, the regenerative divider circuit (figures FO-19 and 4-6) employs a double balanced mixer, Z1, that mixes the incoming vco frequency with one-half the vco frequency which is derived from the if output of the double balanced mixer. The circuit operates as follows: RfamplifierQ3 amplifies the vco frequency and applies it through transformer T1 to the rf port of double balanced mixer Z1. The if output of mixer Z11 feeds rf amplifier Q4 whose output circuit is tuned by transformer T2 and varactor diode CR2 to one-half the vco frequency. When starting up, frequency components at the mixer if output that

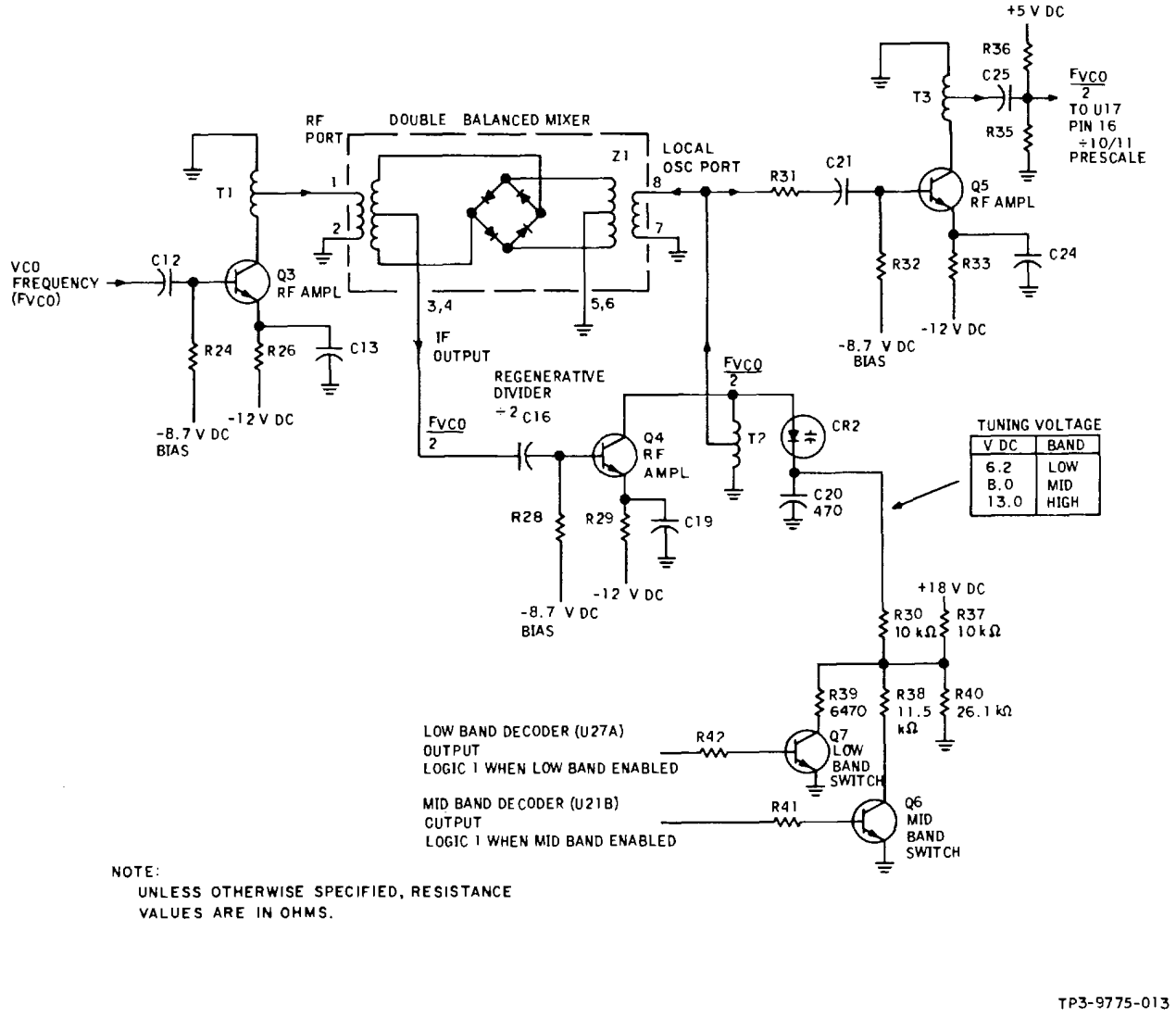

Figure 4-6. Regenerative Divider, Simplified Schematic Diagram

are in the frequency range of one-half the vco frequency are amplified by Q4 and applied to the local oscillator port of mixer Z1. Mixer Z1 mixes the vco frequency with the frequency present at the local oscillator port to produce a difference frequency at the if output. For this circuit to be stable, the frequency present at the if output must be equal to the frequency applied to the local oscillator port. This occurs only when the if output is exactly equal to one-half the vco frequency. (Vco frequency mixed with one-half vco frequency equals one-half vco frequency.) As a result, for any vco frequency applied, the circuit locks up and becomes regenerative at one-half the vco frequency.

4-81. To maintain regeneration over the range of the three voltage-controlled oscillators, varactor CR2 tunes the output tank circuit (T2 and CR2) of Q4 to one-half the center frequency of the frequency band enabled. For high-band vco frequencies (320 to 400 MHz), varactor tuning voltage (about 13 V dc) developed across R40 of voltage divider R37-R40 is applied through resistor R30 to the cathode of varactor CR2. This decreases the capacity of CR2 causing the resonant frequency of T2 and CR2 to be approximately 180 MHz. For midband vco frequencies (250 to 320 MHz), the logic 1 midband decoder output voltage turns midband switch Q6 on. This connects R38 in parallel with R40 to reduce the varactor tuning voltage to

about 8 V dc. This increases the capacitance of varactor CR20 causing the resonant frequency of T2 and CR2 to decrease to approximately 140 MHz. For low-band vco frequencies (195 to 250 MHz), the logic 1 low-band decoder output voltage turns low-band switch Q7 on. This connects R39 in parallel with R40 to reduce the varactor tuning voltage to about 6.2 V dc. This further increases the capacitance of varactor CR20 to reduce the resonant frequency of T2 and CR2 to approximately 110 MHz.

4-82. Rf amplifier Q5 amplifies the half vco frequency output of the regenerative divider and applies the resulting output signal through transformer T3 and coupling capacitor C25 to the ÷10/11 prescaler of the 2-modulus prescaler circuit. Resistors R35 and R36 convert the signal to logic levels compatible (ECL logic) with the ÷10/11 prescaler input.

4-83. Rf amplifiers Q3, Q4, and Q5 operate from the -12-V dc power supply voltage (figure FO-19). Capacitors C28, C62, C15, C18, and C23 and inductors L2, L3, and L4 form a decoupling network to decouple the rf amplifiers from each other and from the -12- V dc line. Zener diode VR3 and resistor R25 develop about -8.7-V dc bias voltage to bias Q3, Q4, and Q5 at approximately 10-milliampere collector current. Capacitors C14, C17, and C22 and inductors L1 and L5 decouple the base circuits of Q3, Q4, and Q5.

4-84. 2-Modulus Prescaler. The 2-modulus prescaler (figures FO-11 and FO-19) consists of a ÷10/11 prescaler (U17), two divide-by-2 flip-flops (U16, U15), and a logical OR control gate(U18B). The 2-modulus prescaler divides by 41 as long as the output of the ÷40 prescale enable gate (U18A) is logic 0. When the output goes to logic 1, the 2-modulus prescaler divides by 40. The following paragraph details the operation of the 2-modulus prescaler.

4-85. The ÷10/11 prescaler, U17, divides by 10 whenever its prescale enable (PE) input is logic 1; otherwise, it divides by 11. As long as the two inputs (waveforms G and H) to the ÷40 prescale enable gate (U18A) are logic 0, the ÷10 prescale enable gate (U18B) decodes the true outputs of U16 and U15 (waveforms C and E) to control the PE input. From the timing diagram (figure FO-11), it can be seen that the ÷10/11 prescaler PE input (waveform Y) is logic 0 only once out of every four count periods of the ÷10/11 prescaler (such as T_0 to T_1 time). Therefore, to get 1 output pulse from the 2-modulus prescaler (waveform F), the ÷10/11 prescaler divides by 10, divides by 10, divides by 11, and divides by 10 for a total count of 41 input pulses. Whenever either input (waveform G or H) to the ÷40 prescale enable gate, U18A, goes to logic 1, the PE input to the ÷10/11 prescaler is held at logic 1 causing the ÷10/11 prescaler to divide by 10 all the time (such as, T_{333} to T_0 time). For this condition, to get 1 output pulse from the 2-modulus prescaler, the ÷10/11 prescaler divides by 10 four times for a total count of 40 input pulses.

4-86. ÷A Programmable Counter. The ÷A programmable counter (figures FO-11 and FO-19) consists of two dual D flip-flops (25-kHz flip-flop U14A and 50-kHz flip-flop U14B) and one programmable decade counter (U13) connected together to form a ÷A down counter. Through frequency select information, the ÷A programmable counter controls the number of times the 2-modulus prescaler divides by 41. The following paragraph details the operation of the ÷A programmable counter for the example frequency of 334.350 MHz.

4-87. Preset pulse W presets the 100-kHz decade counter, U13, to counter state 3. Preset pulse G presets the true output (waveform M) of the 25-kHz flip-flop, U14A, to logic 0 and the true output (waveform P) of the 50-kHz flip-flop, U14B, to logic 1. This, in effect, presets the ÷A programmable counter to a count of 14. For this condition, the borrow output (BO) of the 100-kHz decade counter, U13, is logic 1 causing the output (waveform X) of the modulus control gate, U23D, to be logic 1. This enables the clock enable gate, U23A, and allows pulses (waveform F) from the 2-modulus prescaler to be fed to the clock input of the ÷A programmable counter (waveform I). Also, the logic 1 output of the modulus control gate, U23D, is inverted by U19D and applied as logic 0 (waveform H) to the ÷40 prescale enable gate, U18A. As long as this input and preset pulse G are logic 0, the 2-modulus prescaler will divide by 41. The output of the modulus control gate, U23D, remains at logic 1 until after the ÷A programmable counter has counted 14 input pulses (positive transitions). The counting process can be observed from the timing diagram of figure FO-11. After the 14^{th} pulse, the BO of the 100-kHz decade counter, U13, goes to logic 0 causing the input (waveform R) to the modulus control gate, U23D, to go to logic 1. The next input pulse (positive transition of waveform I) to the ÷A programmable counter causes the false output (waveform J) of the 25-kHz flip-flop, U14A, to go to logic 1 which, in turn, causes the output (waveform X) of the modulus control gate, U23D, to go to logic 0. This inhibits the clock enable gate, U23A, from applying any additional pulses to the clock input of the ÷A programmable counter. This locks up the ÷A programmable counter causing it to remain in its present state until the next preset time. The logic 0 output of the modulus control gate, U23D, is inverted by U19D (waveform H) and applied to the ÷40 prescaler enable gate, U18A, causing its output to go to logic 1 (waveform Y). This enables the 2-modulus prescaler to divide by 40. The 2-modulus prescaler will continue to divide by 40 until the ÷A programmable counter is preset. At the instant the ÷A programmable counter is preset (T_{333} time), waveform H goes to logic 1. The logic 1 preset pulse G keeps the 2-modulus prescaler enabled to divide by 40 during preset time.

4-88. $\div N_p$ Programmable Counter. The $\div N_p$ programmable counter (figures FO-11 and FO-19) consists of two programmable decade down counters (1-MHz decade counter U12 and 10-MHz decade counter U11), two J-K flip-flops connected as a 4-state up counter (100-MHz counter U10, U9). and an ANDed input J-K flip-flop (counter preset flip-flop U8) used as an end-of-count decoder to generate the output pulses to the frequency/phase detector. The 100-MHz counter is programmed by 100-MHz frequency select information to count from state 0 to state 3 for 300-MHz radio control frequencies and from state 1 to state 3 for 200-MHz frequencies. Through frequency select informa-tion, the $\div N_p$ programmable counter is preset to a count that represents the transmit frequency. When the transmitter is unkeyed, control logic reduces the count by 30 to cause a 30-MHz decrease in frequency. The following details the operation of the $\div N_p$ programmable counter for the example frequency of 334.350 MHz. Refer to figure FO-11 for a timing diagram.

4-89. Preset pulse W presets 1-MHz decade counter U12 to counter state 4 and 10-MHz decade counter U11 to counter state 3. Preset pulses G and W preset 100-MHz counter U10-U9 to counter state 0. This, in effect, presets the $\div N_p$ programmable counter to a count of 334. The process of counting input pulses (waveform Z) can be observed from the timing diagram. For the purpose of discussion, these pulses will be referred to as clock pulses.

4-90. For both transmit and receive mode, the count terminates two clock pulses after all inputs (waveforms AK, AL, and AR) to the ANDed J-input of counter preset flip-flop U8 go to logic 1. Waveforms AK and AL from the 100-MHz counter both go to logic 1 after the 235th clock pulse (T235). Waveform AR from the counter preset logic (U20C/D, U25C, and U21B) goes to logic 1 when all inputs (waveforms AA, AC, AD, and AP) to the counter preset logic go to logic 0. This occurs as follows: During transmit mode, the logic 0 key 1 input is inverted by U19A and applied as logic 1 to gate U25D. This enables gate U25D and allows the BO output of 10-MHz decade counter U11 to be applied through gates U25D and U25B to the input of the counter preset logic. This causes waveform AP to go to logic 0 when the BO output (waveform AN) of 10-MHz decade counter U11 goes to logic 0 which occurs after the 327th clock pulse (T327). The other three inputs (waveforms AA, AC, and AD) to the counter preset logic go to logic 0 when the QA, QC, and QD outputs of 1-MHz decade counter U12 go to logic 0. This occurs after the 332nd clock pulse (T332) when the counter reaches state 2. With all inputs to the counter preset logic at logic 0, the output (waveform AR) goes to logic 1 to make the J-input to counter preset flip-flop U8 logic 1.

4-91. During receive mode, waveform AR goes to logic 1, 30 clock pulses sooner than during transmit mode. This is a result of the 30-MHz decoder(U26B, U19F). The 30-MHz decoder decodes the QA, QB, and QC outputs of 10-MHz decade counter U11. After the 295th clock pulse (T295), the outputs QA, QB, and QC of the 10-MHz decade counter U11 (waveforms AE, AF, and AG) go to logic 1, logic 1, and logic 0 respectively. This results in a logic 0 output from the 30-MHz decoder. During receive mode, the logic 1 key 1 input enables gate U25A and allows the logic 0 output of the 30-MHz decoder to be applied through U25A and U25B to the input of the counter preset logic. This causes waveform AP to go to logic 0 when the 30-MHz decoder output goes to logic 0 which occurs after the 295th clock pulse (T295). The other three inputs (waveforms AA, AC, and AD) to the counter preset logic go to logic 0 when the QA, QC, and QD outputs of 1-MHz decade counter U12 go to logic 0. This occurs after 302 clock pulses (T302) when the counter reaches state 2. The output (waveform AR) goes to logic 1 to make the J-input to counter preset flip-flop U8 logic 1.

4-92. With the J-input to counter preset flip-flop U8 at logic 1, the next clock pulse (T_{333} for transmit mode, T_{303} for receive mode) to the $\div N_p$ programmable counter (inverted by U19C and applied to the clock input of U8) causes U8 to change state. This generates the output pulses (waveforms G and W) to the frequency/phase detector which are also the reset pulses. The reset pulses reset the $\div N_p$ programmable counter causing the J-input to counter preset flip-flop U8 to go to logic 0. With the J-input back to logic 0, the next input pulse to the $\div N_p$ programmable counter causes counter preset flip-flop U8 to revert back to its original state to start a new count period. Therefore, for transmit mode, the total number of clock pulses counted by the $\div N_p$ programmable counter is 334 which is equal to the preset count for a frequency of 334.350 MHz. For receive mode, the total number of clock pulses counted is 304, which is 30 less than the preset count.

4-93. REFERENCE DIVIDER AND 3.2-MHz FREQUENCY REFERENCE. The reference divider (figure FO-19) consists of two bcd counters (A2A7U5, A2A7U7) connected to divide by 256. The 3.2-MHz frequency reference consists of a highly stable, temperature-controlled crystal oscillator (A2A8). By dividing the 3.2-MHz frequency reference output by 256, the reference divider provides a highly stable 12.5-kHz signal to one-shot A2A7U4B. The one-shot generates both a logic 1 and logic 0 output pulse at its output for each positive transition at its input. The RC time constant of resistor A2A7R13 and capacitor A2A7C7 determine the pulse width (about 100 microseconds). The logic 1 pulse is applied to the frequency/phase detector reference input. Both pulses are applied to the lock monitor reference input.

4-94. FREQUENCY/PHASE DETECTOR, LIMITER AMPLIFIER, AND LOW-PASS FILTER. Reference designators apply to A2A7. The frequency/phase

detector (figure FO-12) consists of two J-K flip-flops (U3A, U3B), two NAND gates (U2C, U2B), and a cross-coupled NAND gate flip-flop (U2D, U2A). Under phase-locked conditions, variable divider and reference divider input pulses alternate with a certain phase difference between them. From the timing diagram of figure FO-12, it can be observed that variable divider pulses (F_V) set the frequency/phase detector output (waveform C) to a logic 1, and reference divider pulses (F_R) set the output to a logic 0. This produces an asymmetric output waveform with duty cycle that represents the phase error between the two input pulses. Limiter amplifier Q2 inverts and limits the output waveform to specific logic levels before applying it to the low-pass filter. This eliminates amplitude variations in the frequency/phase detector output. The low-pass filter filters the limiter amplifier output waveform to produce a dc tuning voltage to the vco. The level of the dc tuning voltage is proportional to the duty cycle of the waveform.

4-95. LOCK MONITOR. Reference designators apply to A2A7. The lock monitor (figure FO-12) consists of two J-K flip-flops (U6A, U6B), a NOR gate (U20A), and a one-shot (U4A). From the timing diagram, it can be observed that for phase-locked conditions, the J-inputs to flip-flops U6A and U6B are always logic 0 just prior to applications of pulses (F_V and F_R) to their clock inputs. As long as F_V and F_R pulses alternate, the true outputs (waveforms I and J) of U6A and U6B remain at logic 0 and the p11 fault output of one-shot U4A remains at logic 1.

4-96. When the frequency of the variable divider output becomes much greater or much less than the reference divider, the lock monitor indicates a p11 fault. From the timing diagram it can be seen that if the variable divider frequency becomes much greater than the reference divider so that the reference divider (F_R) and variable divider (F_V) pulses no longer alternate, then the second variable divider pulse causes the output of flip-flop U6A to go to logic 1. The resulting negative transition at the input to one-shot U4A causes the one-shot to generate a logic 0 output pulse (about 15 milliseconds wide) to indicate an out-of-lock condition. In a similar manner, if the variable divider frequency becomes much less than the reference divider, the output of flip-flop U6B goes to logic 1 to produce a logic 0 p11 fault output from one-shot U4A. The one-shot is resettable such that each negative transition at its inverting input resets the one-shot to timeout for about 15 milliseconds. Keying the transmitter generates a positive pulse at the non-inverting input to one-shot U4A. This results in a logic 0 p11 fault output from U4A each time the transmitter is keyed. The p11 fault output is applied to the keyer control circuit in audio module A4. When the transmitter is keyed, the logic 0 p11 fault signal inhibits the key line (key 2) to power amplifier A8 for about 15 milliseconds. This allows the frequency synthesizer to stabilize at the transmit frequency before the power amplifier begins transmitting the rf signal

4-97. VOLTAGE REGULATOR. The voltage regulator (A2A7U1, A2A7Q1 of figure FO-19) develops regulated +18 V dc from regulated +22 V dc. Amplifier A2A7U1 compares a reference voltage developed across zener diode A2A7VR1 to a sample of the 18-V dc output developed across voltage divider A2A7R3-R6-R7. The output of A2A7U1 provides base drive to turn on series pass transistor A2A7Q1. Resistor A2A7R7 is test selected to give about +18-V dc output voltage.

4-98. RECEIVER RF MODULE A3.

4-99. Refer to the block diagram of figure FO-6 and schematic diagram of figure FO-20 while reading the following circuit description. Unless otherwise specified, reference designators apply to components of receiver rf module A3.

4-100. GENERAL. Receiver rf module A3 receives AM rf signals from rf filter module A7 and provides detected audio to audio module A4. Refer to block diagram of figure FO-6. The incoming receive rf signal (225.000 to 399.975 MHz) is mixed with the receive injection signal (195.000 to 369.975 MHz) from the synthesizer to produce the 30-MHz if signal. The if signal is filtered, amplified, and separated into two signal paths. The upper signal path feeds the second mixer directly through a filter/delay network and if amplifier. The lower signal path feeds the noise channel if amplifier. The noise channel if amplifier processes impulse type noise to turn off the 19.3-MHz oscillator signal to the second mixer whenever a pulse with certain characteristics is detected. The filter/delay network in the upper signal path slows the noise pulse so that it arrives at the second mixer during the time when the 19.3-MHz oscillator signal is turned off. This circuit action mutes the receive rf so noise pulses do not appear at the output.

4-101. At the second mixer, the 30-MHz if signal is mixed with the 19.3-MHz oscillator signal to produce the 10.7-MHz if signal. The 10.7-MHz if signal is filtered, amplified, and applied to the detector where it is demodulated into an audio signal superimposed on a dc level that is proportional to the average carrier level at the detector. The audio is amplified and fed to the receiver af output. The dc voltage is fed to the AGC circuit where it is integrated, amplified, and applied to if amplifier and shunt attenuator circuits to control receive gain. The integrator provides the proper AGC time constant (attack and release times). AGC voltage is fed to the squelch circuit on audio module A4 to provide receiver squelch control and to rf filter module A7 to provide front-end rf signal attenuation.

4-102. When the transmitter is keyed, the mute circuit increases AGC voltage to force the rf receiver gain to provide maximum attenuation to the receive rf signal. This mutes the receiver.

4-103. The following describes individual circuit functions of receiver rf module A3. Refer to figure FO-20.

4-104. UHF MIXER. The uhf mixer (U1 of figure FO-20) functions as an active balanced mixer to generate the 30-MHz if signal. Capacitor C1 couples the receive rf signal to the signal input port of coupling transformer T1. Transformer T1 transforms the signal into two balanced, 180-degree-phase-related signals and applies them to the source inputs of the two junction field-effect transistors (JFET) of U1. In a similar manner, capacitor C11 couples the receive injection signal through the local oscillator port of T1 to the source inputs of U1. Transformer T1 applies the receive injection signal in phase. The level of the receive injection signal is such that it causes the grounded gate JFET's of U1 to operate in the square law region for mixing action and conversion gain. The uhf mixer provides about 3 dB of gain and, therefore, acts as an rf preamplifier to the receiver rf input signal. The 30-MHz difference frequency appears across the secondary of transformer T2.

4-105. In the uhf mixer circuit, variable capacitors C2 and C12 provide broadband tuning to the input of transformer T1. The capacitors are adjustable to provide maximum flatness of the output signal over the frequency range of the uhf mixer. Capacitors C13 and C19 tune the output of transformer T2 to 30 MHz. Resistor R2 and capacitor C20 decouple the uhf mixer from the +12-V dc line. Resistor R1 provides bias voltage.

4-106. 30-MHz FILTER. The 30-MHz filter (FL3 of figure FO-20) is a single-tuned, high Q filter that passes the 30-MHz difference frequency from the uhf mixer to the first 30-MHz if amplifier. Variable capacitor C10 in parallel with capacitors C78 and C102 and inductor L7 tunes the center frequency of the filter and the output of transformer T2 to 30 MHz. Capacitor C102 provides temperature compensation.

4-107. FIRST 30-MHz IF AMPLIFIER. The first 30- MHz if amplifier (Q1 and Q2 of figure FO-20) is a low-noise rf amplifier that amplifies the 30-MHz if signal by about 14 dB to ensure the remaining if stages will not degrade the overall receiver noise figure. Capacitor C22 couples the 30-MHz if signal from the 30-MHz filter to the base of transistor Q1. Bias amplifier Q2 biases transistor Q1 at approximately 60 milliamperes. Capacitor C23 couples the output of Q1 to the filter/delay circuit (FL2) in the main receiver if channel and through coupling capacitor C102 to the noise channel if amplifier.

4-108. NOISE CHANNEL IF AMPLIFIER (Q3). The noise channel if amplifier (Q3 of figure FO-20) is a self-biased FET rf amplifier circuit with a gain of about 4 dB. Variable capacitor C33 and inductor L22 tune the output of Q3 to 30 MHz. Capacitor C29 and resistor R7 decouple the amplifier from the +12-V dc line. Resistor R8 provides bias voltage.

4-109. NOISE CHANNEL IF AMPLIFIERS (U2, U3). The noise channel if amplifiers (U2 and U3 of figure FO-20) consist of two gain-controlled integrated circuit amplifiers that produce about 40 dB of open loop gain per stage. Capacitor C30 couples the 30-MHz if signal to the first noise channel if amplifier (U2). Capacitor C34 and inductor L23 tune the output of U2 to 30 MHz. Variable capacitor C35 couples the output of U2 to the input of the second noise channel if amplifier (U3) which is tuned to 30 MHz by capacitor C36 and inductor L24. Variable capacitor C41, capacitor C42, and inductor L25 tune the output of U3 to 30 MHz. Variable capacitor C43 couples the output of U3 to the noise channel detector circuit (CR5). Variable capacitors C35 and C43 are adjusted for maximum rf gain through the noise channel if amplifiers. Noise channel AGC voltage developed by the noise channel AGC amplifier is applied through resistors R9 and R11 to control the gain of the noise channel if amplifiers for a nearly constant signal level at the input to the noise channel detector. Capacitors C32 and C104 and resistor R102 form a low-pass filter to decouple the first noise channel if amplifier (U2) from the +12-V dc line. Capacitors C37 and C105 and resistor R103 decouple the second noise channel if amplifier (U3) from the +12-V dc line.

4-110. NOISE CHANNEL DETECTOR. The noise channel detector (CR5 of figure FO-20) demodulates the 30-MHz noise channel if signal and develops the detected signal across capacitor C45. The detected signal contains impulse noise superimposed on a dc level that is proportional to the average carrier level. Bias network R14-CR3-CR4-C40 applies a dc voltage equivalent to two diode drops through inductor L16 to the anode end of noise detector diode CR5. Inductor L26 and capacitor C44 form a parallel resonant circuit at 30 MHz. This provides a low impedance path for the bias voltage and a high impedance path for the 30-MHz if signal. The bias voltage compensates for the diode drop across CR5 and the emitter-to-base junction voltage of the emitter follower (Q4) to bias Q4 at the point of conduction. This makes the noise channel AGC voltage independent of the voltage drop across detector diode CR5 and the base-to-emitter junction of Q4.

4-111. EMITTER FOLLOWER. The emitter follower (Q4 of figure FO-20) provides a high impedance load to the noise channel detector (CR5). The impulse type noise developed across emitter resistor R19 is coupled through a differentiator formed by capacitor C49 and resistor R22 to the noise pulse detector. The dc voltage developed across R19 is applied to the noise channel AGC amplifier (Q5, Q6).

4-112. NOISE CHANNEL AGC AMPLIFIER. The noise channel AGC amplifier (Q5 and Q6 of figure FO-20) is a 2-transistor, dc coupled, high-gain amplifier. The amplifier amplifies small changes in carrier-derived dc voltage developed across resistor R19 into the proper level to control the gain of noise channel if amplifiers U2 and U3. Resistor R13 is test selected to set the noise channel if amplifier gain for optimum noise blanking. Capacitor C46 filters the audio component super-imposed on the dc voltage. Noise blanking can be disabled by applying a ground to the external noise blanker disable line (P1-15). This turns transistor Q6 off which, in turn, causes maximum AGC voltage to be applied to U2 and U3 to mute (disable) the noise channel if amplifier.

4-113. NOISE PULSE DETECTOR. The noise pulse detector (Q7 of figure FO-20) processes impulse type noise to provide a negative-going trigger pulse to the one-shot (Q9, Q8). Capacitor C49 and resistor R22 form a differentiator that is responsive to the fast rise time of impulse type noise but nonresponsive to the slow rise time of voice audio. This allows impulse noise to be coupled to the base of transistor Q7 to turn it on. When Q7 turns on, capacitor C50 (which is charged to about +12 V dc) discharges through Q7 to develop a negative trigger pulse at the base of one-shot transistor Q9. Negative voltage developed across resistor R29 of voltage divider R29-R28 speeds up the discharge of capacitor C50 to produce a fast rise time trigger pulse, and therefore, faster triggering of the one-shot.

4-114. ONE-SHOT. The one-shot circuit (Q8 and Q9 of figure FO-20) is a monostable multivibrator that generates a pulse at the collector of Q9 whenever there is a negative-going trigger pulse applied to the base of Q9. In the stable state, +12 V dc applied through resistor R32 biases Q9 on, and the negative voltage developed across R29 and applied through resistor R30 biases Q8 off. During this time, C51 charges to approximately 12 V dc. Whenever a noise pulse is detected, capacitor C50 couples a negative-going pulse to the base of Q9 causing it to turn off. When Q9 turns off, capacitor C52 couples the rising collector voltage of Q9 to the base of Q8, turning it on. Transistor Q9 collector voltage applied through resistor R33 keeps Q8 biased on once the collector voltage reaches its final value of +12 V dc. With QB on, capacitor C51 applies a negative voltage to the base of Q9 to keep it turned off and the one-shot in its unstable state. Transistor Q9 remains off for the length of time (about 8 microseconds) required for C51 to discharge through R32 and Q8. When C51 begins to charge positive, the positive voltage applied to the base of Q9 turns Q9 on which, in turn, turns Q8 off; and the one-shot reverts back to its stable state. The pulse generated at the collector of Q9 is the noise blanking pulse applied to the noise blanker gate.

4-115. NOISE BLANKER GATE. The noise blanker gate (Q15 of figure FO-20) is a transistor switch that turns the injection amplifier (Q13) off whenever there is a noise blanking pulse generated by the one-shot. The noise blanking pulse applied through R36 causes transistor Q15 to turn on. When on, Q15 shunts base current from transistor Q13 to turn it off. With Q13 off, the 19.3-MHz injection signal to the second mixer is removed causing the receiver to mute for about 8 microseconds. This prevents the noise pulse which initiated the triggering of the one-shot from appearing at the receiver output.

4-116. Applying a ground to the noise blanker disable line or installing a wide bandwidth 10.7-MHz crystal filter (FL1), which has a special grounding pin, disables the noise blanker gate making it nonresponsive to noise blanking pulses from the one-shot.

4-117. FILTER/DELAY. The filter/delay circuit (FL2 of figure FO-20) is a triple-tuned interstage filter that terminates the first if amplifier in the main if channel. The filter/delay provides about a 1.2-microsecond delay to the 30-MHz if signal so that the noise blanking pulse can disable the second mixer before the noise pulse arrives there. Variable capacitors C14, C16, and C18 tune the filter/delay to pass the 30-MHz center frequency and provide about 54-dB rejection of signals at ±1.5 MHz from center frequency. Capacitor C28 couples the output of the filter/delay circuit to the second if amplifier.

4-118. SECOND 30-MHz IF FILTER. The second 30-MHz if amplifier (Q12 of figure FO-20) is a temperature-compensated rf amplifier that compensates for gain variations within the amplifier and second mixer. The room temperature gain is about 8 dB. Thermistor RT1 is the temperature-sensitive component that varies the gain of the amplifier. As the temperature increases, the resistance of RT1 decreases. This causes the ac impedance of the emitter circuit of Q12 to decrease which, in turn, causes the gain of the second 30-MHz if amplifier to increase with temperature. Transformer T3 couples the output of the second 30-MHz if amplifier to the second mixer.

4-119. 19.3-MHz OSCILLATOR AND INJECTION AMPLIFIER. The 19.3-MHz oscillator (Q14 of figure FO-20) is a crystal-controlled oscillator that generates the 19.3-MHz local oscillator frequency for the second mixer. Variable capacitor C71 adjusts the oscillator frequency to exactly 19.3 MHz. The injection amplifier (Q13) amplifies the 19.3-MHz signal to about 2 V rms and applies it to the local oscillator port of the second mixer.

4-120. SECOND MIXER. The second mixer (Q10 and Q11 of figure FO-20) is an active balanced mixer that mixes the 30-MHz if signal with the 19.3-MHz injection signal to produce the 10.7-MHz if signal

The secondary of transformer T3 transforms the 30-MHz if signal into two balanced, 180-degree-phase-related signals and applies them to the gates of FET's Q10 and Q11. Variable capacitor C61 is adjustable to allow balancing of the mixer. The 19.3- MHz injection signal is applied to the sources of FET's Q10 and Q11. The dc level from the injection amplifier provides bias voltage to FET's Q10 and Q11 so that when the 19.3-MHz injection signal is applied, the FET's operate in the square law region for mixing action and conversion gain. The second mixer provides about 12 dB of gain to the if signal. The 10.7-MHz difference frequency is devel-oped across the secondary of transformer T3 and is coupled to the 10.7-MHz crystal filters (FL1). Capacitors C62 and C63 tune the primary of T4 to 10.7 MHz.

4-121. 10.7-MHz CRYSTAL FILTER. The 10.7-MHz crystal filter (FL1 of figure FO-10) determines the receiver selectivity. To be compatible with 50-kHz channel spacing, the filter provides an if bandwidth of ±15 kHz from center frequency with maximum attenua-tion of 2 dB within this bandwidth. At ±18 kHz from center frequency, the filter provides a maximum of 6 dB of attenuation. At ±40 kHz from center frequency, the filter provides a minimum of 80 dB of attenuation. Variable capacitor C64 and test select capacitor C109 tune the filter input while variable capacitor C74 tunes the filter output for minimum ripple through the passband of the filter. Resistors R60 and R61 provide the proper load to terminate the filter.

NOTE

To receive wide bandwidth data, the 10.7-MHz crystal filter can be replaced with a wide bandwidth filter having an if bandwidth of ±25 kHz from center frequency with maximum attenuation of 1 dB. At ±30 kHz from center frequency the wide bandwidth filter provides a maximum of 6 dB of attenuation, and at ±60 kHz from center frequency the filter provides a minimum of 80 dB of attenuation. When installed in the radio set, a special ground pin on the wide-band filter disables the noise blanker circuit.

NOTE

To be compatible with 25-kHz channel spacing, the 10.7-MHz crystal filter can be replaced with a narrow bandwidth filter having an if bandwidth of ±10 kHz from center frequency with maximum attenuation of 6 dB. At ±25 kHz from center frequency the filter provides a minimum of 80 dB of attenuation

4-122. 10.7-MHz IF AMPLIFIER. The 10.7-MHz if amplifier (U4, U5, and Q16 of figure FO-20) consists of two gain-controlled integrated circuit if amplifiers (U4 and U5) and a temperature-compensated transistor if amplifier (Q16) that together provide about 88 dB of open loop gain. Capacitor C75 couples the 10.7-MHz if signal to if amplifier U4. AGC voltage developed by the AGC circuit is applied through resistor R62 to control the gain of U4. Inductor L18 and swamping resistor R65 broadband tune the output of U4 to 10.7 MHz. Resistor R65 is test selected to adjust the 10.7-MHz if amplifier gain to produce an AGC voltage that sets the squelch threshold at about 3 microvolts when the squelch control is set for maximum sensitivity. Capacitor C92, temperature-compensation network RT2-R66-R67, and capacitor C93 couple the output of if amplifier U4 to the input of if amplifier U5. AGC voltage applied through resistor R63 controls the gain of U5. The output of U5 is broadband tuned to 10.7 MHz by inductor L20 and coupled through capacitor C96 to if amplifier Q6. Capacitor C87 and inductor L21 tune the output of Q16 to 10.7 MHz. Capacitor C85 couples the output of Q16 to voltage divider R72-R73 which provides isolation for the 10.7-MHz if output. The signal level at the 10.7-MHz if output is about 10 millivolts when loaded externally by a 50-ohm termination. Capacitor C86 couples the 10.7-MHz if signal to the detector. Temp-erature-compensation network RT3-R71-C84 in the emitter circuit of Q16 and temperature-compensation network RT2-R67-R66 between if amplifiers U4 and U5 improve closed-loop gain characteristics by making the if gain less dependent upon temperature. Low-pass filters L17-C77, L19-C94, and C97-R70 decouple each stage of the 10.7-MHz if amplifier from the ±12-Vdc line.

4-123. DETECTOR. The detector (CR9 of figure FO-20) demodulates the 10.7-MHz if signal and develops the detected signal across RC filter network R75-C89. The detected signal contains the audio signal superimposed on a dc level that is proportional to the carrier level. Bias network R74-CR10-C91 applies a dc voltage equivalent to one diode drop through inductor L29 to the anode end of detector diode CR9. This biases detector diode CR9 at the point of conduction to make the AGC voltage independent of the diode drop across detector diode CR9.

4-124. AF AMPLIFIER. The af amplifier (U6A of figure FO-20) amplifies the detected audio signal and the carrier derived dc voltage by a voltage gain of about 5.6 volts per volt (V/V). Capacitor C90 couples the amplified audio signal through voltage divider R78-R79 to the receiver af output of receiver rf module A3. The audio voltage developed across R79 is about 225 millivolts for a 30-percent modulated receive rf input signal. The amplified dc signal is direct coupled to integrator U6B in the AGC circuit where it is used to develop AGC voltage to control receiver gain

4-125. AGC CIRCUIT. Refer to figure FO-20. The AGC circuit consists of an integrator (U6B), three AGC amplifiers (U7A, U7B, Q17), and two shunt attenuators (CR6, CR1). In addition, a series/shunt attenuator in rf filter module A7 receives AGC voltage to form a part of the overall receiver gain control circuit. This circuit will be discussed as part of rf filter module A7.

4-126. By nature of the AGC circuit, the carrier-derived dc output voltage from af amplifier U6A is automatically held at about 2.5 V dc whenever there is a nonvarying receive rf signal applied to the rf receiver input. This can be seen by considering the operation of integrator U6B. Voltage divider R83-R84 develops an AGC reference voltage (approximately ±2.5 V dc) that is applied through resistor R85 to the noninverting input of integrator U6B. The carrier-derived dc voltage from af amplifier U6A is applied through resistor R81 to the inverting input of U6B. Integrator U6B compares these two voltages and integrates the difference to develop the AGC output voltage. The AGC voltage is inverted and amplified by AGC amplifier U7A and applied through resistors R64, R62, and R63 to the gain control inputs (pin 2) of 10.7-MHz if amplifiers U4 and U5. A portion of the output of U7A is amplified by AGC amplifiers U7B and Q17 and applied as 30-MHz AGC voltage to the two shunt attenuators, CR6 and CR1. Also, the rf attenuator (AGC) voltage output of AGC amplifier U7B is applied to rf filter module A7 to control the series and shunt attenuators in that module.

4-127. To control receiver gain, the integrator output voltage (AGC voltage) settles at whatever AGC voltage necessary to give a carrier-derived voltage from the af amplifier equal to the AGC reference voltage (voltage divider R83-R84). This is the only stable output from the integrator (other than end stops). Any other carrier-derived voltage compared to the AGC reference voltage will cause the integrator to integrate up or down to change the receiver gain until the af amplifier output equals the AGC reference voltage.

4-128. The time constant of integrator U6B determines the attack time and release time of the AGC circuit. Resistor R82 and capacitor C82 set the attack time at about 100 milliseconds. Resistor R81 and capacitor C82 set the release time at about 500 milliseconds. When a signal is first applied to the receiver, the carrier-derived voltage will be large until the AGC voltage reduces the receiver gain. If the carrier-derived voltage exceeds the zener voltage of VR1, it will be applied to integrator U6B through resistor R82, diode CR11, and zener diode VR1. This changes the RC time constant components of integrator U6B from R81 and C82 to R82 and C82 to control the attack time. Once the receiver has stabilized and the carrier-derived voltage settles back to about 2.5 V dc, integrator U6B components R81 and C82 determine the release time.

4-129. Receiver gain is controlled in stages. Over the range from about 3 to about 10 microvolts at the antenna, the 10.7-MHz AGC voltage applied to the 10.7-MHz if amplifiers controls receiver gain. Once the input signal exceeds 10 microvolts, the gain of the 10.7-MHz if amplifiers is varied slower, and the rf attenuator (AGC) voltage applied to the series attenuator in the rf filter module controls most of the receiver gain up to approximately 100-microvolt input signal. At that point, the series attenuator reaches maximum attenuation. Above 100 microvolts, the rf attenuator voltage applied to the shunt attenuator in the rf filter module and the 30-MHz AGC voltage applied to the two shunt attenuators of the receiver rf module control receiver gain.

4-130. The 10.7-MHz AGC voltage that controls the first stage of gain reduction is developed as follows: The AGC voltage at the output of integrator U6B (test point 10) varies from about -0.65 to about -4.4 V dc for input signal variations from 1 microvolt to 1 volt. AGC amplifier U7A amplifies this AGC voltage to produce the 10.7-MHz AGC voltage that is applied to 10.7-MHz if amplifiers U4 and U5. For AGC voltages that range from 0 to -1 V dc, the gain of amplifier U7A is about 7.5 V/V. For AGC voltages above -1 V dc, zener diode VR2 begins to conduct to change the gain of U7A to about 0.25 V/V. This nonlinear gain characteristic causes the 10.7- MHz AGC voltage to increase from 0 to about 7.8 V dc for an increase in AGC voltage from 0 to -1 V dc respectively. Above -1 V dc, the 10.7-MHz AGC voltage only increases to about 8.6 V dc for a -4.4 V dc AGC voltage. This results in a 0- to approximately 20-dB receiver gain reduction by the 10.7-MHz if amplifier for the first volt of AGC voltage and a nearly constant 20-dB gain reduction for AGC voltage above -1 V dc.

4-131. The rf attenuator (AGC) voltage that controls the second stage of gain reduction is developed as follows: AGC amplifier U7B, which has a gain factor of about 5.2 V/V, amplifies a divided down portion of the 10.7-MHz AGC voltage from U7A. Through voltage divider action of resistors R90 and R91 across 7.5 V dc zener diode VR2, the voltage developed across resistor R90 is about 0.4 V dc whenever the AGC voltage exceeds -1 V dc. This voltage in conjunction with the reduced gain of U7A (about 0.25 V/V when AGC voltage exceeds -1 V dc) results in a positive voltage at the noninverting input of U7B that varies from about 0.65 to about 0.9 V dc as the AGC voltage increases from -1 to -2 V dc. When amplified by U7B, the resulting rf attenuator (AGC) voltage applied to the rf filter module varies from about 3.5 V dc for -1 V dc of AGC voltage to about 4.7 V dc for -2 V dc of AGC voltage. This voltage is in the active range of the series attenuator in the

rf filter module. The series attenuator begins to provide attenuation to the rf signal when rf attenuator (AGC) voltage exceeds about 3.4 V dc and provides maximum attenuation after the voltage exceeds approximately 5 V dc. Refer to the circuit description of rf filter module A7 (paragraph 4-221) for circuit operation of the series attenuator. The gain reduction by the 10.7-MHz if amplifiers and the gain reduction by the series attenuator overlap so there is a smooth transition at the crossover point.

4-132. For AGC voltage above -2 volts, the third stage of gain reduction is controlled by rf attenuator (AGC) voltage applied to the shunt attenuator in the rf filter module and by 30-MHz AGC voltage applied to shunt attenuators (CR1 and CR6) in the receiver rf module. Refer to the circuit description of rf filter module A7 (paragraph 4-221) for circuit operation of the shunt attenuator in that module. In receiver rf module A3, the shunt attenuator (CR1) at the output of the uhf mixer (U1) functions as follows: When forward biased, pin diode CR1 acts as an rf attenuator by shunting part of the 30-MHz if signal to ground through capacitor C21. The amount of attenuation is controlled by the amount of forward bias applied through the parallel combination of diode CR2 and resistor R25. For 30-MHz AGC voltage below about 3.8 V dc, negative voltage developed across resistor R26 of voltage divider R24-R26 reverse biases CR1 so that it offers no attenuation to the 30-MHz if signal. As the 30-MHz AGC voltage increases above 3.8 V dc, pin diode CR1 becomes forward biased to begin attenuating the 30-MHz if signal. Maximum attenuation (approximately 25 dB of receiver gain reduction) is attained when the AGC voltage exceeds about 4.4 V dc. In a similar manner, pin diode CR6 attenuates the 30-MHz if signal at the output of the second if amplifier (Q12).

4-133. The 30-MHz AGC voltage is developed as follows: When the AGC voltage is -1 V dc, AGC amplifier Q17 amplifies the output of U7B to produce a 30-MHz AGC voltage of about 3.4 V dc. This is just below the turn-on point of the shunt attenuators. As AGC voltage increases above -1 V dc, pin diodes CR1 and CR2 of the shunt attenuators begin to turn on to provide receiver gain reduction. Once the receiver input signal increases to the point where the AGC voltage exceeds about -2 V dc, the 30-MHz AGC voltage exceeds 4.7 V dc and the shunt attenuators (including the shunt attenuator of rf filter module A7) take over to provide receiver gain reduction. The gain reduction of the series attenuator overlaps the gain reduction of the shunt attenuators so there is a smooth transition of the crossover point.

4-134. RECEIVER MUTE. The receiver mute circuit (Q19 and Q18 of figure FO-20) turns down the receiver gain to mute the receiver whenever the transmitter is keyed. When the transmitter is keyed, the ground applied through resistor R98 turns mute transistor Q19 off. This turns mute switch Q18 on. When on, Q18 applies about 9 V dc to the 10.7-MHz AGC line which, in turn, causes AGC amplifiers U7B and Q17 to apply about 10 V dc to the 30-MHz AGC line and about 11 V dc to the rf attenuator (AGC) line. This high AGC voltage mutes the receiver by turning the receiver gain down to provide maximum attenuation to the rf signal.

4-135. AUDIO MODULE A4.

4-136. Refer to the block diagram of figure FO-7 and schematic diagram of figure FO-21 while reading the following circuit description. Unless otherwise specified, reference designators apply to components of audio module A4.

4-137. GENERAL. Audio module A4 is composed of a transmit audio circuit, receive audio circuit with squelch, a ptt keyer circuit, and a keyer control circuit. The transmit audio circuit receives voice audio from the main audio input and microphone input or wide bandwidth data from the data audio input. Voice audio that can range in level from -15 to +10 dB mW is coupled through the input transformer to the audio level strapping circuit. For normal strapping, the voice audio is attenuated by 20 dB and applied to the compression amplifier. For voice audio levels that range from -35 to -15 dB mW, optional audio level strapping couples the signal directly to the compression amplifier without attenuation. To prevent overmodulation of the transmitter, the compression amplifier maintains a constant output level for input levels that vary from -35 to +10 dB mW depending on the strapping option used. In addition, the compression amplifier amplifies the microphone input to hold microphone audio at the same constant output level. The constant level output signal from the compression amplifier is passed through a low-pass filter followed by a high-pass filter to shape the audio response so that the modulation amplitude does not vary by more than +1 to -2 dB from 300 to 6000 Hz. The output of the high-pass filter passes through a second high-pass filter to the percent modulation control. The percent modulation control sets the modulation audio level to modulate the transmitter at the desired modulation percentage. The output of the percent modulation control is passed through a clipper to remove audio peaks that could overmodulate the transmitter. The output of the clipper passes through a second low-pass filter to provide transmit audio to the modulator circuit of power amplifier module A8. The second high-pass and low-pass filters have no effect (other than signal amplification) on the audio response of the voice audio since they have cutoff frequencies of 16 Hz and 25 kHz respectively. These filters shape the frequency response of the wide bandwidth data so that the modulation amplitude does not vary by more than -1 to -3 dB from 16 Hz to 25 kHz. The modulation level of the wide bandwidth data is set by a potentiometer at the data audio input.

4-138. The receive audio circuit receives detected audio (receive af input) from receiver rf module A3. The receive af signal is amplified and passed through the bandpass filter to the receive data audio output. The bandpass filter shapes the response of the signal so that its amplitude does not vary by more than +1 to -3 dB from 16 Hz to 25 kHz. The receive af signal is also applied to the compression amplifier. The compression amplifier maintains a constant output level for input audio levels that vary as a function of the percent modulation of the receive rf signal. The constant level output signal from the compression amplifier is passed through a high-pass filter followed by a low-pass filter to shape the audio response of the signal so that the signal amplitude does not vary by more than +1 or -2 dB from 300 to 3000 Hz. The audio level from the low-pass filter is adjusted by the headset volume control and applied to the power amplifier to drive the headset. Also, the audio level from the low-pass filter is adjusted by the receive audio level control and applied to a second power amplifier to set the audio level at the main audio output. Both outputs are capable of 100 milliwatts of output power.

4-139. During transmit mode, transmit audio is detected at the antenna (rf filter module A7) and fed back as sidetone audio. This audio is applied to the amplifier in the compression amplifier circuit so that sidetone audio can be heard at the receive audio output (headset).

4-140. The squelch control and squelch gate provide receiver muting. AGC voltage that is related to rf signal strength is compared by the squelch control to the squelch reference input (squelch potentiometer) that sets the squelch threshold. When the rf input signal to the radio set decreases below the squelch threshold, as set by the squelch potentiometer, the squelch gate mutes the receiver. The squelch on/off line disables the squelch gate whenever the squelch is turned off.

4-141. Keying information received at the main audio input is applied to the ptt keyer. The ptt keyer has strapping options that allow selection of normal ground ptt keying or optional 6-, 26-, or 48-volt keying. The remote ptt output of the keyer is connected to the REMOTE/LOCAL switch (front panel of chassis A10) which applies the remote ptt keying signal to the ptt input of the keying control circuit whenever the radio set is operating in the remote mode.

4-142. The keying control circuit receives ptt keying and radio set fault information and provides at its output two transmitter key lines and a fault switch circuit. The fault switch circuit turns on the ready lamp (radio control for remote operation or front panel of chassis A10 for local operation). When a synthesizer fault (ptt fault input) or rf filter servo fault (rf filter fault input) is detected, the ready lamp is turned off and the key 2 key line is inhibited by the keyer control circuit.

4-143. The following describes individual circuit functions of audio module A4. Refer to figure FO-21.

4-144. INPUT TRANSFORMER AND AUDIO LEVEL STRAPPING. Transformer T1 (figure FO-21) terminates 150- or 600-ohm main audio input lines. Connected in series (P1-C to P1-D), the primary windings of T1 provides 600-ohm termination; individually, the primary windings provide 150-ohm termination. Voice audio applied to the main audio input is coupled through transformer T1 to the audio level strapping circuit where voltage divider R2-R3-R4 attenuates the -15- to +10-dB mW audio signal by about 20 dB (normal strapping). The attenuated audio signal (-35 to -10 dB mW) is applied to the variable attenuator (R6-Q1) of the compression amplifier circuit. For -35- to -15-dB mW voice audio input signals, the optional -35-dB mW audio level strapping (strap E2 to E3 removed and strap E1 to E2 added) applies the output of T1 directly to the variable attenuator.

4-145. The microphone input is coupled directly to the variable attenuator through coupling capacitor C1 and resistor R7. A -12 V dc applied through resistors R10 and R11 provide dc current to the carbon microphone. Resistor R10 provides a load to the microphone.

4-146. COMPRESSION AMPLIFIER (TRANSMIT AUDIO). The transmit audio compression amplifier (figure FO-21) consists of the variable attenuator circuit (Q1), amplifier circuit (U1A), and detector circuit (U2A, U2B, Q2, Q3). Functionally, the circuit maintains a nearly constant audio output signal (about 180 millivolts rms at test point TP16) for audio input signals (test point TP6) that range from about 14 (-35 dB mW) to about 245 millivolts (-15 dB mW). Compression is achieved by controlling the attenuation ratio of variable attenuator Q1 which in turn controls the level of audio applied to amplifier U1A. Positive or negative audio peaks from the output of amplifier U1A that exceed the threshold of the detector (about 250 millivolts peak or 180 millivolts rms) are converted into a dc control voltage and applied to the gate of variable attenuator Q1 to control the attenuation ratio of the variable attenuator. As the audio input signal increases, the detector reduces the control voltage applied to the variable attenuator to increase its attenuation ratio. This reduces and maintains the audio level at the input to amplifier U1A at the level necessary to hold the output of the amplifier just at the detector threshold. The compression amplifier attack time is about 4 milliseconds; release time is about 150 milliseconds.

4-147. Variable Attenuator. The variable attenuator consists of resistor R6 and FET Q1 that together function as a variable voltage divider. The drain to source resistance of FET Q1 varies from infinity to

approximately 100 ohms as the detector-developed control voltage applied to its gate varies from -12 V dc to 0 volt. Through voltage divider action, the audio signal applied to the noninverting input of amplifier U1A decreases as the detector output voltage decreases toward zero.

4-148. Amplifier. Amplifier U1A provides a voltage gain of about 57 V/V. Together, the variable attenuator and amplifier provide a variable compression amplifier gain that varies from about 57 to less than 1. The minimum gain depends upon the minimum turn-on resistance of FET Q1.

4-149. Detector. The detector circuit (U2A, U2B, Q2, and Q3) functions as a peak waveform detector to reduce compression amplifier gain whenever positive or negative audio peaks at the output of amplifier U1A try to exceed the detector threshold (approximately 0.25 volt). Resistor R22 of voltage divider R21-R22 sets the detector threshold by developing a bias voltage of about -0.23 V dc that is applied to the inverting inputs of amplifiers U2A and U2B. Each amplifier amplifies the bias voltage by a voltage gain of about 15.4 V/V to produce a positive output voltage of about 3.55 V dc. The high positive voltage biases transistors Q2 and Q3 into cutoff. With Q2 and Q3 off, -12-V dc power supply voltage applied through resistor R24 charges capacitor C9 to about -12 V dc. This voltage, when applied to the gate of FET Q1, results in maximum FET resistance and therefore maximum compression amplifier gain. When audio is applied to the compression amplifier, the audio signal present at the output of amplifier U1A is coupled to the inverting input of amplifier U2A through capacitor C4 and resistor R15 and to the noninverting input of amplifier U2B through capacitor C5. Each amplifier amplifies the audio signal by a gain of about 16.2 V/V to produce an ac output voltage that is superimposed on the amplified bias voltage applied to Q2 and Q3. When positive peaks of the output audio signal from U1A exceed the detector threshold, the ac output voltage from U2A forward biases Q2 for the period of time the peak voltage exceeds the threshold. In the same manner, when negative peaks exceed the detector threshold, the ac output voltage from U2B forward bias Q3. When Q2 and/or Q3 are forward biased, they turn on and allow capacitor C9 to discharge through resistor R23. The ratio of on time to off time determines the average negative voltage developed across C9. This voltage, when applied to the variable attenuator (gate of Q1), controls the compression amplifier gain to maintain the peak voltage at the output of U1A at the detector threshold. Through this circuit action, the compression amplifier output voltage is held at about 180 millivolts (rms) for the approximate 14- to 250-millivolt range of audio input signals.

4-150. Resistors R24 and R23 and capacitor C9 determine the attack and release time of the compression amplifier. When audio is first applied or the level of audio is increased, the fast discharge of capacitor C9 through resistor R23 sets the attack time at about 4 milliseconds. When audio is removed or the level is decreased, the slow charge of C9 through R24 sets the release time at about 150 milliseconds.

4-151. LOW-PASS FILTER (U1B). The low-pass filter (U1B of figure FO-21) shapes the high-frequency response of the output signal from the transmit audio compression amplifier. The low-pass filter is a 3-pole, active filter with unity gain and cutoff frequency of 6 kHz. The three poles are determined by resistor-capacitor networks R12-C10, R13-C11, and R14-C12. In the passband, the output varies less than +1 or -2 dB when referenced to the output at 1000 Hz. In the stopband, the output is down greater than -10 dB at 10 kHz.

4-152. HIGH-PASS FILTER (U7B). The high-pass filter (U7B of figure FO-21) shapes the low-frequency response of the output signal from the compression amplifier that is passed through the low-pass filter (U1B). The high-pass filter is a 3-pole, active filter with a voltage gain of about 3.9 V/V and cutoff frequency of 300 Hz. The three poles are determined by resistor-capacitor networks R62-C28, R63-C29, and R64-C30. In the passband, the output varies less than +1 or -2 dB when referenced to the output at 1000 Hz. In the stopband, the output is down greater than -10 dB at 100 Hz.

4-153. HIGH-PASS FILTER (U3). The high-pass filter (U3 of figure FO-21) shapes the low-frequency response of the wide bandwidth data applied at the data audio input. The high-pass filter is a 3-pole, active filter with a voltage gain of about 9 V/V and cutoff frequency of 16 Hz. The three poles are determined by resistor-capacitor networks R26-C14, R28-C15, and R27-C16. In the passband, the filter response varies less than +1 or -3 dB when referenced to the output at 1000 Hz. Because of the low cutoff frequency, high-pass filter U3 does not affect the frequency response of the voice audio signal from high-pass filter U7B. It does, however, amplify the voice audio signal by a voltage gain of about 9. Variable resistor R107 allows the output of the high-pass filter to be set up for proper modulation level when transmitting wide bandwidth data.

4-154. PERCENT MODULATION CONTROL. The transmit audio output signal from audio module A4 (A4P1-13/A10J13-13) is fed to the percent modulation (% MOD) control located on the front panel of receiver-transmitter. The percent modulation control allows adjustment of the audio level applied to the modulator circuit of power amplifier A8 to set up the modulation percent of the transmitted rf signal. The percent modulation control (figure FO-16) consists of resistors A10A1R6 and A10A1R7 and variable resistor A10A1R2. Resistor A10A1R7 and

variable resistor A10A1R2 are connected to give fine control for high percentages of modulation and course control for low percentages of modulation. Resistor A10A1R6 in parallel with A10A1R7 provides a nearly constant load to the audio signal from the audio module. The variable audio output from the modulation control is applied to the clipper and low-pass filter circuits (A4P1-14/A10J13-14) of audio module A4.

4-155. CLIPPER AND LOW-PASS FILTER (U7A). To prevent overmodulation of the transmitter, the clipper (CR3 and CR4 of figure FO-21) removes excessive voltage peaks that may be present on the transmit audio signal. The output of the clipper is applied through voltage divider R31-R32 to the low-pass filter (U7A). The voltage divider attenuates the audio signal by a factor of about 0.24 before applying the signal to the low-pass filter.

4-156. The low-pass filter (U7A of figure FO-21) shapes the high-frequency response of the wide bandwidth data to be transmitted. The filter is a 2-pole, active filter with unity gain and cutoff frequency of 25 kHz. The two poles are determined by resistor-capacitor networks R33-C64 and R35-C65. In the passband, the filter response varies less than +1 or -3 dB when referenced to the output at 1000 Hz. Because of the high cutoff frequency, high-pass filter U7A does not affect the frequency response of the voice audio signal to be transmitted.

4-157. REMOTE PTT KEYER. The remote ptt keyer (Q4 and Q5 of figure FO-21) converts external keying information applied to the center tap of the main audio input (P1-C or P1-D) into remote ptt keying (P1-A). When operating in the remote mode, the remote ptt output is applied to the keying control circuit input (P1-K). Figure FO-16 shows the interconnection between the remote ptt keyer and the keying control circuit. Strapping options on audio module A4 provide for selection of the following types of external keying: normal ground keying or optional 6-, 26-, or 48-volt keying. Strapping as shown on figure FO-21 provides for ground keying. When a ground is applied (keyed) to pin C or D of P1, keyer driver transistor Q4 turns on to forward bias ptt keyer transistor Q5 turning it on. When on, Q5 applies a ground to the ptt input (P1-K) of the keying control circuit to key the radio set (remote operation). When the ground is removed (unkeyed) from pin C or D of P1, +22 V dc applied through resistors R111, R36, and R37 reverse bias diodes CR1 and CR2. This prevents key-line noise from turning on keyer driver transistor Q4 which is reverse biased by +5 V dc applied through resistors R38 and R39. When Q4 turns off, ptt keyer transistor Q5 turns off to unkey the radio set.

4-158. Optional 6-Volt Remote Keying. For 6-volt keying, straps E4 to E5, E6 to E7, and E8 to E9 are removed and strap E13 to E10 is added. This removes keyer driver transistor Q4 from the remote ptt keyer circuit and adds a voltage divider composed of resistor R109 (P1-C) or R110 (P1-D) in series with zener diode VR7 and resistors R40 and R41. For this strapping option, ptt keyer transistor Q5 turns on whenever the keying voltage applied to pin C or pin D of P1 exceeds about 4.6 volts.

4-159. Optional 26-Volt Remote Keying. For 26-volt keying, straps E4 to E5. E6 to E7, and E8 to E9 are removed and strap E13 to E11 is added. This removes keyer driver transistor Q4 from the remote ptt keyer circuit and adds a voltage divider composed of resistor R109 or R110 in series with zener diode VR5 and resistors R40 and R41. For this strapping option, ptt keyer transistor Q5 turns on whenever the keying voltage applied to pin C or pin D of P1 exceeds about 22 volts.

4-160. Optional 48-Volt Remote Keying. For 48-volt keying, straps E4 to E5, E6 to E7, and E8 to E9 are removed and strap E13 to E 12 is added. This removes keyer driver transistor Q4 from the remote ptt keyer driver and adds a voltage divider composed of resistor R109 or R110 in series with zener diode VR6 and resistors R40 and R41. For this strapping option, ptt keyer transistor Q5 turns on whenever the keying voltage applied to pin C or pin D of P1 exceeds about 35 volts.

4-161. The remote ptt keyer output (P1-A) is connected to the REMOTE/LOCAL switch (A10A1S3 of figure FO-16) located on the front panel of chassis A10. When in the remote position, the remote ptt keying signal is applied to the ptt input (P1-K) of the keyer control circuit.

4-162. KEYING CONTROL CIRCUIT. The keying control circuit (Q6, Q7, Q8, Q9, and Q10 of figure FO-21) converts ptt keying into two key-line circuits (key 1 and key 2) and one ready lamp circuit. Key 1 key line provides fast attack-slow release keying to the 30-MHz frequency shift circuit of frequency synthesizer module A2, the receiver mute circuit of receiver rf module A3, and transmit/receive switch in rf filter module A7. Key 2 key line provides slow attack- fast release keying to the transmit/receive switch of frequency synthesizer module A2 and to the ALC circuit of power amplifier module A8. In addition, when a fault is detected in the phase locked loop (p11 fault), or in the rf filter (rf filter fault), or in the d/a servo amplifier circuit (rf filter fault), the keying control circuit inhibits grounding of the key 2 key line and turns off the ready lamp.

4-163. When the ptt fault (P1-L) and rf filter fault (P1-10) inputs are both logic 1 (no fault), fault switch Q8 is on and key 2 inhibit transistor Q9 is off. When on, fault switch Q8 provides a ground to the ready lamp circuit to turn on the radio control

ready lamp (remote operation) or chassis A10 ready lamp (local operation). Figure FO-16 shows ready lamp circuit. When off, key 2 inhibit transistor Q9 allows keyer transistor Q10 to be turned on and off by key driver transistor Q6. Under the above conditions, a ground applied to the ptt input (P1-K) turns key driver transistor Q6 on which, in turn, turns keyer transistors Q7 and Q10 on to ground the key 1 (P1-5) and key 2 (P1-M) key lines. When a fault is detected, the logic 0 fault signal applied to the p11 fault or rf filter fault inputs turns fault switch Q8 off. This ungrounds the ready lamp circuit to turn off the ready lamp. In addition, Q8 turns on key 2 inhibit transistor Q9 to turn off keyer transistor Q10. This ungrounds the key 2 key line to unkey the power amplifier. Key 1 key line remains grounded to mute the receiver.

4-164. Capacitor C21, diode CR6, and resistors R46 and R47 provide fast attack-slow release keying to the key 1 keyer circuit. When Q6 turns on (ptt input grounded), the fast charge of capacitor C21 through CR6 provides fast attack to ground key 1. When Q6 turns off, the slow discharge (relative to charge time) of capacitor C21 through R46 and R47 provides slow release to unground key 1.

4-165. Capacitor C22 and resistors R45 and R50 provide slow attack-fast release keying to the key 2 keyer circuit. When Q6 turns on, the charge of capacitor C22 through resistor R45 provides slow attack to ground key 2. When Q6 turns off, the fast discharge (relative to charge time) of capacitor C22 through R50 provides fast release to unground key 2.

4-166. BANDPASS FILTER/'AMPLIFIER. The bandpass filter/amplifier (U4 of figure FO-21) amplifies and shapes the frequency response of the received wide bandwidth data signal from receiver rf module A3 (receive af input, P1-7). The filter is a 6-pole, active filter with a voltage gain of about 4.2 V/V and cutoff frequencies of 16 Hz and 25 kHz. The three poles that control the low-frequency response are determined by resistor-capacitor networks R57-C23, R56-C24, and R58-C25. The three poles that control the high-frequency response are determined by resistor-capacitor networks R112-C69, R113-C70, and R114-C67. In the passband, the output varies less than +1 or -3 dB when referenced to the output at 1000 Hz.

4-167. Bias voltage of about +0.64 V dc developed across resistor R59 of voltage divider R60-R59 biases the output voltage of U4 to approximately 5 volts with no input audio signal. This allows the output of U4 a maximum swing of approximately ±17 volts when an audio input signal is applied.

4-168. Capacitor C32 couples the output of U4 to the receive data audio output (P1-15) through impedance matching pad R65-R66 and transient protection circuit VR3-VR4. Pad R65-R66 provides a 10-kilohm load to the receive data output line. Zener diodes VR3 and VR4 provide protection to the audio circuit against high-voltage noise spikes that may be present on the receive data audio output line from the radio set.

4-169. COMPRESSION AMPLIFIER (RECEIVE AUDIO). The receive audio compression amplifier (figure FO-21) is composed of the variable attenuator circuit (Q11), amplifier circuit (U5A), and detector circuit (Q13). Functionally, the compression amplifier maintains a constant (within 3 dB) audio output signal (about 1.6 volts rms at test point TP13) for voice audio input signals (receive af input, P1-7) that vary as a result of the percent modulation of the received rf signal. Compression begins when the input signal exceeds about 0.22 volt rms.

4-170. Compression is achieved by controlling the attenuation ratio of variable attenuator Q11 which in turn controls the level of audio applied to amplifier U5A. Negative audio peaks that exceed the threshold of detector Q13 (about 2.24 volts peak or 1.6 V rms) are converted into a dc control voltage and applied to the gate of variable attenuator FET Q11 to control the attenuation ratio of the variable attenuator. As the audio input signal increases, detector Q13 decreases the control voltage applied to the gate of variable attenuator Q11 to increase its attenuation ratio. This reduces and maintains the audio level applied to the amplifier input at the level necessary to hold the output of the amplifier just at the detector threshold. The compression amplifier has an attack time of about 4 milliseconds and a release time of about 150 milliseconds.

4-171. Variable Attenuator. The variable attenuator is composed of resistors R67 and R68 and FET Q11 that together function as a variable voltage divider. FET Q11 acts as a variable resistor that changes from infinite resistances to some finite value as the detector-developed control voltage applied to its gate decreases from -12 V dc toward 0 volt.

4-172. Amplifier. Amplifier U5A provides a voltage gain of about 48 V/V. Together, the variable attenuator and amplifier provide a variable compression amplifier gain that varies from about 7.1 V/V to less than 0.64 V/V. The minimum gain depends upon the minimum turn-on resistance of FET Q11. In addition, amplifier U5A provides a voltage gain of about 3.7 V/V to sidetone audio. During transmit mode, transmit audio detected at the antenna (rf filter module) is fed back and inserted into the receive audio path at this point so that it appears as sidetone in the audio output. Receive audio is muted by receiver rf module A3 during this time. During receive mode, sidetone mute switch Q18 is turned on by the logic 1 key 1 key line. This grounds the sidetone input to amplifier U5A.

4-173. Detector. The detector circuit functions as a peak detector to reduce compression amplifier gain whenever negative audio peaks at the output of amplifier U5A try to exceed the detector threshold (approximately -2.24 volts). Resistor R74 of voltage divider R75-R74 sets the detector threshold by developing a bias voltage of about +1.54 V dc that reverse biases transistor Q13. With Q13 off, -12-V dc power supply voltage applied through resistor R76 charges capacitor C36 to about -12 V dc to turn FET Q11 completely off. When audio is applied to the compression amplifier, output audio from U5A appears at the base of transistor Q13 superimposed on the bias voltage. When negative audio peaks exceed about -2.24 volts, the voltage applied to the base of Q13 exceeds the bias voltage plus base-to-emitter junction voltage of Q13. This brings Q13 into conduction to allow capacitor C36 to discharge through resistor R117 for the length of time Q13 is turned on. The ratio of on time to off time determines the average negative voltage developed across C36. This voltage, when applied to the variable attenuator (gate of Q11), controls the compression amplifier gain to maintain negative peaks at the output of amplifier U5A at about -2.24 volts. Through this circuit action, the audio output of the compression is held at about 1.6 V rms over the range of the variable attenuator which is approximately 25 dB. Diodes CR10 and CR11 clip positive peaks that exceed approximately 3 volts. Capacitor C72, resistor R121, and diode CR14 comprise an averaging detector which reduces the reverse-bias voltage on Q13 when receiving a high peak-to-average receive audio signal. This regulates the compression amplifier output and compensates for average power output changes that would occur between high peak-to-average and low peak-to-average receive audio signals.

4-174. Resistors R117 and R76 and capacitor C36 determine the attack and release time of the compression amplifier. When audio is first applied to the compression amplifier or the level of audio increases, the fast discharge of capacitor C36 through resistor R117 sets the attack time at about 4 milliseconds. When audio is removed or the level of audio decreases, the slow charge of C36 through R76 sets the release time at about 150 milliseconds.

4-175. SQUELCH CIRCUIT. Refer to figures FO-21 and 4-7. The squelch control (U5B) compares AGC voltage to a squelch reference input voltage from the squelch potentiometer (A10A1R1 of figure 4-7) to mute the receiver whenever the rf input signal to the receiver is below squelch threshold as determined by the squelch potentiometer setting. Summing network R79-R80 compares negative AGC voltage (squelch sample) to the positive squelch reference bias developed across resistor R82 and applies the resulting sum to the inverting input of squelch control U5B. Squelch reference bias developed across R82 of voltage divider R82-R83-R81 varies from about +0.29 volt for minimum setting of squelch potentiometer A10A1R4 (maximum squelch sensitivity) to about +1.35 volts for maximum setting of A10A1R4 (minimum squelch sensitivity). For no rf input signal or for rf input signals below squelch threshold, the absolute value of the negative AGC voltage is less than the positive squelch reference bias. This results in a positive voltage at the summing point of R79 and R80 and, thus, a negative output voltage from U5B (approximately -10 Vdc). This forward biases squelch gate Q12 to turn it on. When on, Q12 shunts receive audio to ground to mute the receiver output. When the rf input signal exceeds the squelch reference, the voltage applied to U5B goes negative. This causes the output of U5B to go positive (approximately +10 V dc) to reverse bias Q12 and unmute the receive audio. To prevent random muting of the receiver when the rf input is right at squelch threshold, resistors R84 and R85 form a positive feedback path around U5B to provide about 20 millivolts of hysteresis to the input signal.

4.176. A ground on the squelch on/off line disables the squelch circuit by grounding the base of squelch gate Q12. Thus unmutes the receive audio independently of the output of squelch control U5B.

4-177. HIGH-PASS FILTER (U6A). The high-pass filter (U6A of figure FO-21) shapes the low-frequency response of the output signal from the receive audio compression amplifier. The high-pass filter is a 3-pole, active filter with unity gain and cutoff frequency of 300 Hz. The three poles are determined by resistor-capacity networks R86-C39, R88-C40, and R87-C41. In the passband, the output varies less than +1 or -2 dB when referenced to the output at 1000 Hz. In the stopband, the output is down more than -10 dB at 10 kHz.

4-178. LOW-PASS FILTER (U6B). The low-pass filter (U6B of figure FO-21) shapes the high-frequency response of the output signal from the compression amplifier that is passed through the high-pass filter (U6A). The low-pass filter is a 3-pole, active filter with unity gain and cutoff frequency of 3000 Hz. The three poles are determined by resistor-capacity networks R-89-C43, R90-C45-C44, and R91-C46. In the passband, the output varies less than +1 or -2 dB when referenced to the output at 1000 Hz. In the stopband, the output is down more than -10 dB at 10 kHz.

4-179. HEADSET VOLUME AND RECEIVE AUDIO LEVEL CONTROLS. The output signal (audio to gain controls) from audio module A4 (A4P1-S/A10J13-S) is fed to the headset volume control (VOL) and the receive audio level control (RCV AUDIO) located on the front panel of the receiver-transmitter. The headset volume control (A10A1R1 of figure FO-15) allows adjustment of the audio level to the headset. The receive audio level control (A10A1R3 of figure FO-15)

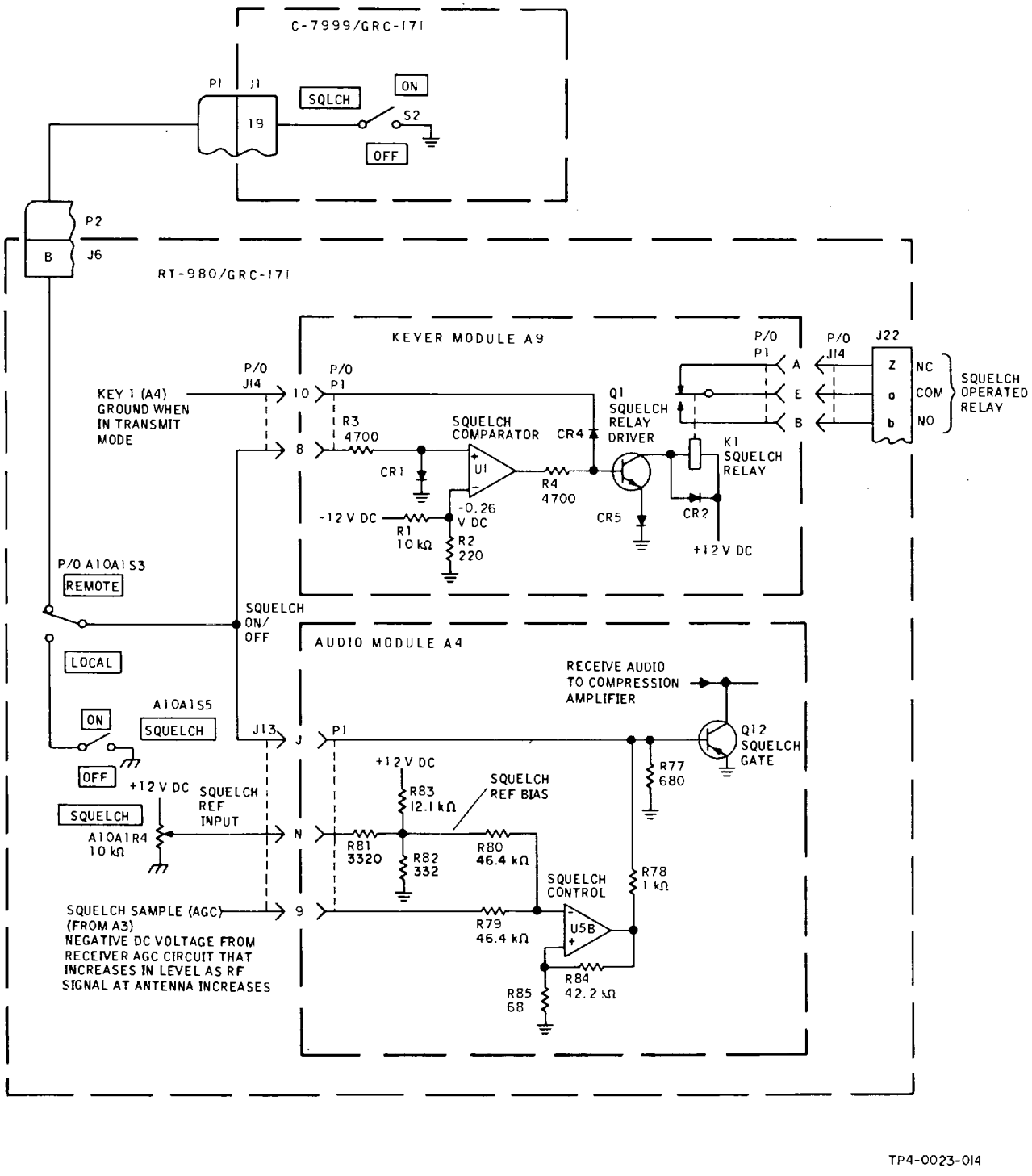

Figure 4-7. Squelch Circuit, Simplified Schematic Diagram

allows adjustment of the receive audio output from the radio set. The variable output of the headset volume control is applied to the headset gain input (A4P1-22/A10J13-22) of audio module A4. The variable output of the receive audio level control is applied to the main af gain input (A4P1-T,/'A10J13-T) of audio module A4.

4-180. HEADSET POWER AMPLIFIER. The headset power amplifier (U8A, Q16, and Q17 of figure FO-21) amplifies the headset gain input signal to provide a 100-milliwatt minimum headset audio output signal to the headset when the headset volume control is set at maximum volume. Capacitor C55 couples the input signal through resistor R98 to audio amplifier U8A that drives complementary output transistors Q16 and Q17. Resistors R98 and R104 determine the power amplifier gain and improve crossover distortion of Q16 and Q17. Resistors R102 and R103 in the emitter circuit of Q16 and Q17 provide thermal stability. Resistor R105 and capacitor C57 improve high-frequency stability. Transformer T3 matches the output impedance of the power amplifier to the 600-ohm load of the headset.

4-181. MAIN AUDIO POWER AMPLIFIER. The main audio power amplifier (U8B, Q14, and Q15 of figure FO-21) amplifies the main af gain input signal to provide a 100-milliwatt minimum main audio output signal (into 600 ohms) when the receive audio level control is set at maximum level. The circuit functions identically to the headset power amplifier. Diodes CR12 and CR13 provide transient protection to the power amplifier against high-voltage noise spikes that may be present on the receive audio output lines from the radio set.

4-182. DC-DC CONVERTER MODULE A5.

4-183. GENERAL. Dc-dc converter module A5 (figures FO-8 and FO-22) contains two dc-dc converters. One dc-dc converter is a switching regulator type converter that remote senses its output voltage to provide a regulated +26-V dc voltage to power amplifier module A8 and to other circuits of the receiver-transmitter. The second dc-dc converter is a nonregulating, saturating core type converter that provides +10 and -17 V dc to voltage regulator module A6, and 100 V dc to rf filter module A7.

4-184. The regulating dc-dc converter (figure FO-8) functions as follows: When input voltage (+25 to +50 V dc unregulated) is first applied to the converter, the startup regulator develops a regulated voltage of about 21 V dc from the unregulated input. This voltage is applied to the dc power supply which develops +20 V dc, (goes to +25 V dc once dc-dc converter output goes to 26 V dc), +12 V dc, and +5.1 V dc to power circuits internal to the dc-dc converter module. With voltage applied, the 40-kHz multivibrator generates a 40-kHz timing signal to provide basic timing for the dc-dc converter. In addition, the 40-kHz timing signal provides switching voltage to the -5.1-V dc converter to convert +12 V dc into a -5.1-V dc power supply voltage. When the radio set is turned off (remote on/off line at ground), the dc- dc converter is in the standby state (startup regulator turned off and the dc-dc converter output at 0 volt). Removing the ground from the remote on/off line turns on the startup regulator and causes the voltage monitor output to enable the pulse width gate. This in turn enables the dc-dc converter to provide +26-V dc regulated output voltage at its output. Once this occurs, the 26-V dc output voltage is fed back (boot-strapped) to the dc power supply to develop the internally-used 25-V dc output voltage.

4-185. The following discussion assumes the dc-dc converter has been on long enough to reach steady-state regulation. Refer to the functional diagram of figure FO-13. Regulation is achieved by remote sensing the output voltage at the load. The error amplifier (A5A1V4A) compares the remote sense voltage to a reference voltage to produce an output voltage sense level (e). Fluctuations in output voltage at the load appear as changes in the voltage sense level ($\pm\Delta e$ error voltages). The voltage comparator (A1U3B) compares the voltage sense level to a ramp voltage generated by the reference ramp circuit (A5A1U5B, A5A1Q13, A5A1VR11). To develop the ramp voltage, the reference ramp circuit processes the 40-kHz timing signal and the input voltage level to provide a ramp voltage with 40-kHz timing and a slope that is a function of the input voltage level. This provides for input regulation of the dc-dc converter. By comparing the voltage sense level to the reference ramp voltage, the voltage comparator generates a 40-kHz output switching voltage. The duty cycle of the switching voltage is a function of changes in the dc-dc converter output voltage or changes in input voltage. Refer to the function diagram of figure FO-13 for effects that changes in input or output voltage have on the duty cycle. The output of the voltage comparator is inverted and applied to the pulse width gate (A5A1U5A) where it is NANDed with the 40-kHz timing signal and the logic 1 voltage monitor (A5A1U4B) output. The positive edge of the resulting 40-kHz output signal moves right or left with respect to changes in dc-dc converter input or output voltages. Approximately the last 4 microseconds of the positive half of the signal is always held in logic 1. This is dead zone time which will be discussed later. The output of the pulse width gate is applied to the on-time switches (A5A1U1B, A5A1Q10, A5A1Q11) and off-time switch A5A1Q17/Q12). The negative edge of the signal controls the on-time switches. The moving positive edge controls the off-time switch. The moving positive edge, therefore, controls the on time to off time ratio of the output switching circuit

4-186. To understand how regulation is achieved, the switching action of the output switching circuits

will be discussed. Refer to figures FO-13 and FO-22. Without getting into detailed circuit theory at this time, on-time switch A1Q11 turns output transistor switch A5Q2/Q3 on. This allows current from the unregulated input to flow through the top half of step-up autotransformer A5T1. Off-time switch A5A1Q17/Q12 turns output transistor switch A5Q2/Q3 off to disrupt the current flow. For one cycle of the pulse width gate output signal, output transistor switch A5Q2/Q3 turns on and off, the length of on time being determined by the duty cycle of the signal. In a similar manner at the beginning of the next cycle, on-time switch A5A1Q10 turns output transistor switch A5Q4/Q6 on. This allows current to flow through the lower half of step-up autotransformer A5T1. Off-time switch A5A1Q17/Q12 turns output transistor switch A5Q4/Q6 off. For this cycle of the pulse width gate output signal, output transistor switch A5Q4/Q6 turns on then off. This alternating action of turning A5Q2/Q3 on then off and then A5Q4/Q6 on then off develops a variable pulse width voltage across step-up autotransformer A5T1. The induced ac voltage across A5T1 is rectified and filtered into an average dc voltage. To summarize the regulating process of the dc-dc converter, variations in output voltage are remote sensed and used to vary the duty cycle of the 40-kHz switching voltage that controls the on time of the output transistor switches. The output transistor switches alternately turn on and off to apply voltage to the load in the form of voltage pulses that vary in width as a function of the remote sensed voltage. By filtering the voltage pulses, the output voltage at the load appears as dc with the level being a function of the voltage pulse width. As load voltage variations are sensed, the pulse width is varied to counteract the voltage change and maintain a nearly constant dc voltage level at the load.

4-187. The instantaneous current comparator (A5A1U3A) and average current comparator (A5A1U6) provide overcurrent circuit protection (current limiting). Output current from the dc-dc converter is sensed by current sense transformer A5T2. The induced ac voltage is rectified, filtered, and applied to the two comparators as an average current sense voltage and an instantaneous current sense voltage. The average current comparator receives the average current sense voltage and compares it to a current reference voltage that determines the average output current limit of the dc-dc converter (about 15 amperes). Whenever the output current exceeds the average current limit, the average current sense voltage exceeds the average current reference voltage. When this occurs for longer than several cycles of the switching frequency, the output of the average current comparator decreases toward zero which causes the voltage sense level to decrease. This in effect reduces the output voltage of the dc-dc converter (26 volt) such that the average current remains at the average current limit point. In a similar manner the instantaneous current comparator receives the instantaneous current sense voltage and compares it to an instantaneous current reference voltage that determines the maximum peak output current limit (about 20 amperes). When the peak output current exceeds the current limit, the output of the current comparator goes positive to turn off the output transistor switch (A5Q2/Q3 or A5Q4/Q6) that is on at that instant. The instantaneous current limit is set higher than the average current limit so that transitory overcurrent conditions that are greater than the average current limit but less than the instantaneous current limit do not affect the dc-dc converter output.

4-188. The voltage monitor (A5A1U4B) monitors for invalid power supply voltages, excessive input voltage, or a grounded remote on/off line. Should a power supply voltage be invalid, or the input voltage exceed about 64 V dc, or the remote on/off line go to ground, the output of the voltage monitor will go to 0 volt to inhibit the pulse width gate. This shuts down the dc-dc converter output by turning both output transistor switches (A5Q2/Q3 and A5Q4./Q6) off.

4-189. The following describes individual circuit functions of the dc-dc converter module. Refer to figure FO-22.

4-190. STARTUP REGULATOR. The startup regulator (A5Q5, A5A1Q4, and A5A1Q15 of figure FO-22) produces a regulated output voltage (about 21 V dc) for input voltages that vary from 25 to 50 V dc. Removing the ground from the remote on/off line allows a reference voltage (about 12 V dc) to be developed across zener diode A5A1VR3 and applied to the base of transistors A5A1Q15. Transistor A5A1Q15 functions as an error amplifier by comparing the reference voltage to a sample of the output voltage developed across resistor A5A1R11 of voltage divider A5A1R63-A5A1R11. The output voltage at the emitter of A5Q5 increases until the voltage drop across A5A1R11 is one base-to-emitter drop less than the reference voltage (about 11.5 V dc across A5A1R11 or about 21 V dc at the emitter of A5Q5). At this point, A5A1Q15 controls the base current to A5A1Q4 and A5Q5 to hold the output at about 21 V dc. The output of the startup regulator is applied to the dc power supply and to the voltage monitor.

4-191. DC POWER SUPPLY. The dc power supply (A5Q1 and A5A1VR5 of figure FO-22) receives voltage from the startup regulator through diode A5A1CR53 to produce +5.1-, 12-, and 25-V dc regulated output voltages. The 25-V dc output is approximately 20 V dc when being supplied from the startup regulator. Once the dc-dc converter provides a regulated output, 26-V dc output voltage is applied through diode A5A1CR22 and choke A5A1L2 to back-bias diode A5A1CR53 and to supply input voltage to the dc power supply

4-192. 40-kHz MULTIVIBRATOR. The 40-kHz multivibrator (A5A1U2) generates an asymmetrical, nominal 40-kHz output waveform to provide basic timing for the dc-dc converter. Resistor A5A1R39 and capacitor A5A1C29 set the low-level time of the waveform to about 4 microseconds. Resistors A5A1R38 and A5A1R39 and capacitor A5A1C29 set the high-level time to about 21 microseconds. Resistor A5A1R38 is test selected for an output frequency of 39.2 to 40.8 kHz.

4-193. -5.1-V DC CONVERTER. The -5.1-V dc converter (A5A1U1A, A5A1Q6, A5A1Q7, and A5A1Q8 of figure FO-22) converts the 12-V dc power supply voltage to a -5.1-V dc power supply voltage. Flip-flop A5A1U1A receives the 40-kHz timing signal to produce a symmetrical, 20-kHz switching voltage to the base of transistor A5A1Q8. This switches A5A1Q8 on and off at the 20-kHz rate which, in turn, alternately switches transistors A5A1Q6 and A5A1Q7 on. When A5A1Q6 is on, capacitor A5A1C19 charges through diode A5A1CR25 to approximately 10 V dc. When A5A1Q7 is on, A5A1C19 discharges through A5A1C20, A5A1R16, and A5A1CR24. This action causes A5A1C20 to charge toward -10 V dc. Zener diode A5A1VR9 clamps the output to about -5.1 V dc.

4-194. VOLTAGE MONITOR. The voltage monitor (A5A1U4B, A5A1Q9, and A5A1VR10 of figure FO-22) compares power supply voltages to produce a validity signal (logic 1) to enable the pulse width gate (A5A1U5A). In addition, the voltage monitor monitors the remote on/off line and 25- to 50-V dc unregulated input line. With the remote on/off line open and all power supply voltages valid, the output of A5A1U4B is low (approximately -3.6 V dc). This back-biases diode A5A1CR55 causing transistor A5A1Q9 to be turned off. The positive collector voltage of A5A1Q9 back-biases diode A5A1CR49 and A5A1CR50 and enables pulse width gate A5A1U5A. If a power supply voltage becomes invalid, the output of A5A1U4B goes high (approximately 10 Vdc). This forward biases A5A1CR55 to turn on A5A1Q9. When on, A5A1Q9 forward biases A5A1CR49 and A5A1CR5[0] and inhibits pulse width gate A5A1U5A to shut down the dc-dc converter. Forward-biased diode A5A1CR50 discharges capacitor A5A1C34 to decrease the voltage sense level to about 0 V dc. Forward-biased diode A5A1CR49 decreases the current reference voltage to about 0 V dc. Reducing these voltages to near zero allows the output of the dc-dc converter to come up slowly once the fault is removed. Capacitor A5A1C23 and resistors A5A1R24 and A5A1R25 form a fast attack-slow release time for momentary faults.

4-195. Zener diode A5A1VR10 monitors the 25- to 50-V dc unregulated input voltage. Input voltages which exceed about 64 V dc cause A5A1VR10 to conduct and forward bias A5A1Q9. This turns A5A1Q9 on to shut down the dc-dc converter until the overvoltage condition is removed. Resistor A5A1R41 is test selected to set the trip lever at 64 ±0.5-V dc input voltage.

4-196. ERROR AMPLIFIER. The error amplifier (A5A1U4A of figure FO-22) compares the remote sensed dc-dc converter output voltage to a reference voltage developed across zener diode A5A1VR12 (about 6.2 V dc). The amplified difference voltage determines the voltage sense level at the input to voltage comparator A5A1U3. For nominal input voltage to the dc-dc converter, the voltage sense level determines the quiescent output voltage from the dc-dc converter. Test select resistors A5A1R53 and A5A1R54 allow adjustment of the error amplifier gain to set the voltage sense level for 26 ±0.15-V dc at the dc-dc converter output. Fluctuations in output voltage appear as error voltage around the voltage sense level. At the input to the voltage comparator, diode A5A1CR52 clamps the maximum voltage sense level to about +5.7 V dc. Diode A5A1CR51 clamps the minimum voltage sense level to about -0.6 V dc. Resistor A5A1R49 and capacitor A5A1C34 provide lag for closed-loop stability.

4-197. VOLTAGE COMPARATOR AND REFERENCE RAMP. The voltage comparator (A5A1U3B of figure FO-22) converts voltage changes at its input into a variable duty cycle waveform that drives the output switching circuits to maintain regulation. The variable duty cycle waveform is generated by comparing the voltage sense level from error amplifier A5A1U4A to the positive ramp voltage developed across capacitor A5A1C33 of the reference ramp circuit (A5A1Q13, A5A1U5B).

4-198. To develop the ramp voltage, A5A1U5B inverts the 40-kHz timing signal to provide a nominal 40-kHz switch voltage at the base of A5A1Q13. The 40-kHz timing signal causes the A5A1Q13 to turn on for about 4 microseconds and off for about 21 microseconds. When A5A1Q13 turns on, A5A1C33 discharges rapidly to ground through diode A5A1CR48. When A5A1Q13 turns off, the dc-dc converter input voltage applied through resistors A5A1R44 and A5A1R45 charges A5A1C33 for about 21 microseconds. Since the RC time constant of the charge path is about 88 microseconds, the voltage developed across A5A1C33 for 21 microseconds approximates a ramp voltage. The slope of the ramp voltage is a function of the dc voltage level applied to the input to the dc-dc converter. Zener diode A5A1VR11 limits the maximum ramp voltage to about 6.2 V dc.

4-199. By comparing the voltage sense level to the ramp voltage, the voltage comparator (A5A1U3B) generates an output waveform that changes from low level to high level at the point where the ramp voltage level equals the voltage sense level. Refer to waveforms of figure FO-13. Since the ramp

voltage varies as a function of input voltage applied to the dc-dc converter and the voltage sense level varies as a function of the output voltage from the converter, the duty cycle of the voltage comparator output is a function of variations in both input and output voltages. The variable duty cycle signal, when applied to the output switching circuits, controls switching times to counteract the voltage variations that originally caused the change in duty cycle.

4-200. AVERAGE CURRENT COMPARATOR. The average current comparator (A5A1U6 of figure FO-22) compares a current sense voltage derived from actual output current flow from the dc-dc converter to an average current reference voltage that determines the average current limit of the dc-dc converter. The average current reference voltage (about 1.5 V dc) is developed through voltage divider action of resistors A5A1R46, A5A1R47, A5A1R48, and A5A1R70 and is applied to the noninverting input of A5A1U6. Resistor A5A1R47 is test selected to set the average output current limit of the dc-dc converter module to about 15 amperes. To develop the average current sense voltage, current sense transformer A5T2 senses current flow through the turned-on output transistor switch (A5Q2/Q3 or A5Q4/Q6). The resulting ac voltage from A5T2 is full-wave rectified by diodes A5A1CR31 through A5A1CR34 and applied to a fast attack-slow release peak voltage detector composed of diode A5A1CR13, resistor A5A1R67, and capacitor A5A1C39. The dc voltage developed across resistor A5A1R67 and stored by capacitor A5A1C39 is the average current sense voltage and is proportional to the level of current flow through the output transistor switches. This voltage, when applied through resistor A5A1R68 to the inverting input of A5A1U6, is compared by A5A1U6 to the average current reference voltage. When the average current sense voltage (output current) is less than the average current reference voltage (output current limit), the output voltage from A5A1U6 is positive enough to reverse bias diode A5A1CR14. With A5A1CR14 reverse biased, the output of A5A1U6 has no effect on the input voltage to A1U3B. As the output current increases and approaches the current limit point, the increase in average current sense voltage causes the output of A5A1U6 to become less positive and forward biases A5A1CR14. With A5A1CR14 forward biased, the output of A5A1U6 takes control of the voltage sense level input to voltage comparator A5A1U3B. When this occurs, output current flow, as opposed to output voltage level, controls the duty cycle of the voltage com- parator output. Any additional increase in output current flow causes the duty cycle (on time of output switching transistors) to decrease. The reduction in duty cycle lowers the output voltage and causes the average output current to start limiting at approximately 15 amperes. Due to resistor A5A1R75 feeding back output voltage to the current reference input to A5A1U6, the output current limit point will lower and cause the actual current limit to be about 12 amperes.

4-201. INSTANTANEOUS CURRENT COMPARATOR The instantaneous current comparator (A5A1U3A of figure FO-22) compares a current sense voltage derived from actual output current flow from the dc-dc converter to a reference voltage that determines the instantaneous (peak) current limit of the dc-dc converter. The instantaneous current reference voltage (about 2 V dc) is developed through voltage divider action of resistors A5A1R46, A5A1R47, A5A1R48, and A5A1R70 and is applied to the inverting input of A5A1U3A. The voltage divider sets the instantaneous current limit (about 20 amperes peak) higher than the average current limit. To develop the instantaneous current sense voltage, current sense transformer A5T2 senses current flow through the turned-on output transistor switch (A5Q2/Q3 or A5Q4/'Q6). The resulting ac voltage from A5T2 is full-wave rectified by diodes A5A1CR31 through A5A1CR34 and applied through diode A5A1CR53 to the noninverting input of A5A1U3A. When the instantan-eous current sense voltage (peak output current) exceeds the current reference voltage (peak current limit), the output of A5A1U3A goes positive. Transistor A5A1Q14 inverts the positive voltage and applies a logic 0 voltage to the input of pulse width gate A5A1U5A. This causes the output of the pulse width gate to go to a logic 1 to turn off the output transistor switch that is on at that instant. This circuit action will continue until the overload condition goes away and the peak output current becomes less than the current limit.

4-202. To prevent the voltage and current comparators from tripping more than once per period of the 40-kHz timing signal, diode A5A1CR47 makes the comparator circuit self-latching. When the output of either the voltage comparator or current comparator goes positive, the positive voltage is fed back through A5A1CR47 to the noninverting input of A5A1U3A. This latches the output of A5A1U3A positive. The latch is reset by the 40-kHz timing signal during dead zone time. Application of the 0-voltage portion of the 40-kHz timing signal to the strobe input of A5A1U3 (pins 2 and 8) forces the output of A5A1U3 to 0 volt independent of its inputs.

4-203. PULSE WIDTH GATE. Pulse width gate A5A1U5A NANDs the inverted (by A5A1Q14), variable duty cycle signal from the output of the voltage/current comparator (A5A1U3) with the 40-kHz timing signal and the voltage monitor output signal. Whenever the output of the voltage monitor is valid (logic 1), A5A1U5A applies the variable duty cycle signal to the output switching circuit. During the logic 0 portion of the variable duty cycle signal, one of the output transistor switches (A5Q2/Q3 or A5Q4/Q6) is on the length of time determined by the width of the logic 0 pulse. During the logic 1 portion of the variable duty

cycle signal, both output transistor switches are off. The 40-kHz timing signal assures both output transistors are turned off for approximately 4 microseconds out of each switching cycle. This is dead zone time which allows the output switching circuit to settle. The voltage monitor output, when logic 0, shuts down the dc-dc converter by causing the output of A5A1U5A to remain at logic 1.

4-204. OUTPUT SWITCHING CIRCUIT. Refer to figure FO-22. The dc-dc converter output switching circuit consists of the following functional circuits: on-time switches A5A1QO1, A5A1Q11; off-time switch A5A1Q17/Q12; current base drive transformer A5T3; output transistor switches A5Q2/Q3 and A5Q4/Q5; step-up autotransformer A5T2, and rectifier/filter A5CR15-CR16, A5L1-A10C14 (capacitor A10C14 is located on the chassis). Because of their interrelationship, these circuits will be discussed as one unit.

4-205. In general, the output switching circuit functions as follows: On-time switch A5A1Q11 controls the turn-on time of output transistor switch A5Q2/Q3. On-time switch A5A1Q10 controls the turn-on time of output transistor switch A5Q4/Q6. Only one transistor is on at any one time. Off-time switch A5A1Q17/Q12 controls the turnoff time of both A5Q2/Q3 and A5Q4/Q6. Current base drive transformer A5T3 couples start and stop base drive signals from the on-time and off-time switches to the base circuits of A5Q2/Q3 and A5Q4/Q6 to switch them on and off. In addition, A5T3 couples back a base drive signal to sustain base drive once A5Q2/Q3 or A5Q4/Q6 is turned on. Step-up auto-transformer A5T1 combines the current flow through A5Q2/Q3 and A5Q4/Q6 into a stepped up ac voltage (actually a series of variable width, voltage pulses). Rectifier diodes A5CR15 and A5CR16 and low-pass filter A5L1-A10C14 rectify and filter the ac voltage into an average dc output voltage from the dc-dc converter.

4-206. The variable duty cycle waveform from pulse width gate A5A1U5A is fed to both the on-time switching circuit (A5A1U1B, A5A1Q10, and A5A1Q11) and off-time switching circuit (A5A1Q17/Q12). In the on-time switching circuit, each logic 1 to logic 0 transition applied to the clock input of flip-flop A5A1U15 causes its outputs to change state. This results in a 20-kHz square wave at the true and false outputs of A5A1U1B. Because of the frequency division, one complete cycle of the output switching circuit requires two cycles of the variable duty cycle waveform. As a starting point, assume that the first logic 1 to logic 0 transition causes the false output of A5A1U1B to change from logic 1 to logic 0. The negative-going transition is coupled through capacitor A5A1C26 causing base current to flow in on-time switch A5A1Q11. This turns A5A1Q1 on for the length of time required for A5A1C26 to charge. At the same time, the logic 0 to logic 1 transition from the true output of A5A1U1B is coupled through capacitor A5A1C25 to reverse bias on-time switch A5A1Q10. This keeps A5A1Q10 turned off. When A5A1Q11 turns on, a pulse of current (startup pulse current) flows through winding 4-3 of A5T3 to ground. This induces a positive voltage across A5T3 winding 7-6 (plus at 7) and a negative voltage across winding 8-9 (negative at 8). The positive-induced voltage turns A5Q2/Q3 on. The negative-induced voltage charges capacitors A5A3C3, A5A3C13, and A5A3C14 through resistor to develop a negative voltage at the base of A5Q4,/Q6. This assures A5Q4/Q6 remains turned off while A5Q2/Q3 is turned on. When A5Q2,/Q3 turns on, current flow through winding 11-10 of A5T3 induces a positive voltage across winding 7-6 (plus to 7) to keep A5Q2/Q3 turned on once the startup pulse terminates. Transistor switch A5Q2/Q3 remains on until off-time switch A5A1Q17/Q12 turns it off.

4-207. In the off-time switching circuit, the logic 1 to logic 0 transition from pulse width gate A5A1U5A that turned A5A1Q11 on, also applies a ground to the cathode end of diode A5A1CR42. This back-biases diode A5A1CR43 causing A5A1Q17/Q12 to be turned off as long as the signal is at logic 0. When the output of pulse width gate A5A1U5A changes from logic 0 to logic 1, the ground is removed from A5A1CR42. This results in the reverse biasing of A5A1CR42 and forward biasing of A5A1CR43 to turn A5A1Q17/Q12 on. When on, A5A1Q12 shorts winding 1-5 to A5T3 to ground through diodes A5A1CR45 and A5A1CR46. The shorted primary winding of A5T3 squelches the induced voltage in the secondary winding causing A5Q2/Q3 to turn off.

4-208. This completes one-half cycle of the output switching sequence. For one complete cycle of the variable duty cycle waveform (output of A5A1U5A), output transistor switch A5Q2/Q3 turns on, then off, to allow current flow through winding 1-2 of step-up auto-transformer A5T1. This induces a positive-to- negative voltage pulse across winding 4-2 of A5T1 that appears at low-pass filter A5L1-A10OC14 through forward-biased rectifier diode A5CR15.

4-209. In a similar manner, the next cycle of the variable duty cycle waveform controls the on time of output transistor switch A5Q4/Q6. The logic 1 to logic 0 transition causes flip-flop A5A1U1B to change state. The resulting logic 1 to logic 0 transition from the true output of A5A1U1B turns on-time switch A5A1Q10 on allowing a pulse of current to flow through winding 2-3 of A5T3. The induced positive voltage across winding 8-9 (plus at 8) turns A5Q4/Q6 on. Once A5Q4/Q6 turns on, current flow through winding 12-13 of A5T3 induces a positive voltage across winding 8-9 to keep A5Q4/Q6 turned on. Off-time switch A5A1Q17/Q12 turns A5Q4/-Q6 off when the variable duty cycle waveform changes from logic 0 to logic 1. The current flow through

A5T1 while A5Q4/Q6 is on induces a positive-to-negative voltage pulse across terminals 5 and 2 of A5T3. This positive voltage appears at low-pass filter A5L1-A10C14 through forward-biased rectifier diode A5CR16.

4-210. Since the variable edge of the 40-kHz variable duty cycle waveform controls the off-time switch, voltage is only applied to the low-pass filter during the time when output transistor switch A5Q2/Q3 or A5Q4/Q6 is turned on. No voltage is applied for the remainder of the 40-kHz period. This results in a voltage in the form 40-kHz pulses, but due to the filter action of filter choke A5L1 and chassis A10 filter capacitor C14, the voltage pulses appear at the load as an average dc voltage level that is a function of the voltage pulse width. Through remote sensing, the dc-dc converter varies the width of the voltage pulse to maintain an average +26-V dc output voltage.

4-211. Zener diodes A5A3VR11 and A5A3VR2 across output transistor switches A5Q2/Q3 and A5Q4/Q6 limit the voltage applied across these transistors to about 140 V dc when they are turned off. Resistor-capacitor networks A5A3R59-C15, A5A3R57-C4, A5A3R60-C16, A5A3R58-C5, A5A3R1-C8, and A5A3R2-C9 suppress switching transients to protect the transistors from damage that could result from overvoltage conditions.

4-212. OVERVOLTAGE CROWBAR. Overvoltage crowbar A5A1Q16 shuts the output switching circuit off if the output voltage exceeds approximately 30 V dc. Zener diode A5A1VR13 conducts when the output voltage exceeds the zener voltage of about 30 volts. This develops a voltage across resistor A5A1R60 which fires SCR A5A1Q16. When A5A1Q16 fires, it grounds the primary winding of current base drive transformer A5T3. This squelches base drive to A5Q2/Q3 and A5Q4/Q6 causing whichever transistor pair is turned on, to turn off.

4-213. VOLTAGE REGULATOR MODULE A6.

4-214. GENERAL. Refer to figure FO-23. Voltage regulator module A6 consists of four series regulators, a zener diode regulator, and a 1-diode-drop voltage source. The four series pass regulators receive 10-, 26- and 17-V dc unregulated voltage from dc-dc converter module A5 and provide 5.1-, 12-, -12-, and 22-V dc regulated voltage to circuits of the receiver-transmitter. The zener diode (VR1) regulator develops about +14 V dc from the 26-V dc input. The 1-diode-drop voltage source (A6A2R1-R2-CR1) develops about -1.0 V dc from the -12-V dc output. This output is named -0.7 V dc throughout the radio set. Diode A6A2CR2 prevents the voltage from going positive by more than about +0.7 V dc

4-215. Since circuit operation of all four series regulators is functionally the same, only the +12-V dc series regulator will be discussed in detail.

4-216. +12-V SERIES REGULATOR. Refer to figure 4-8. A 26-V dc input voltage is applied to transistor Q3 of the +12-V series regulator. To develop the +12-V dc output voltage, a sample of the output voltage is developed across resistors R12 and R13 of voltage divider R11-R12-R13 and applied to the inverting input of the error amplifier of U2. A stable reference voltage of about 7.15 V dc is developed by U2 and applied to the noninverting input of the error amplifier. The error amplifier compares the sample of the output voltage developed across R12 and R13 to the reference voltage and applies the result to the base of the series pass transistor of U2. The series pass transistor controls base current to transistor Q3 to control the output voltage. Resistors R12 and R13 are test selected to set the output voltage to about +12 V dc. To achieve regulation, small changes in output voltage are amplified by the error amplifier to control base current to Q3. If the output voltage tries to increase, the error amplifier output decreases to reduce base current to Q3. This causes Q3 to conduct less to bring the output voltage back to +12 V dc. The opposite occurs if the output tries to decrease.

4-217. Current limiting resistor R10 limits the output current from the +12-V series regulator to approximately 1.6 amperes. Current flow through R10 develops a voltage drop which is applied between the base and emitter of the current limiting transistor of U2. When the output current begins to exceed approximately 1.6 amperes, the voltage drop across R10 begins to forward bias the current limiting transistor and turn it on. When on, the current limiting transistor shunts base current from the series pass transistor causing it to reduce base current to Q3. This decreases collector current through Q3 to limit the current through resistor R10 to approximately 1.6 amperes.

4-218. -12-V SERIES REGULATOR. Circuit operation of the -12-V series regulator is similar to that of the +12-V series regulator (paragraph 4-216). Resistors R17 and R18 are test selected to set the output voltage to approximately -12 V dc. Voltage sensed across resistor R16 limits the output current to about 1.6 amperes.

4-219. +5.1-V SERIES REGULATOR. Circuit operation of the +5.1-V series regulator is similar to that of the +12-V dc series regulator (paragraph 4-216) with the exception that voltage divider R4-R5-R6 divides down the internal reference voltage of U1 to set the output voltage. Resistors R4 and R5 are test selected to set the output voltage of the +5.1-V series regulator to approximately +5.1 V dc. Voltage sensed across resistor R3 limits the output current to about 5.3 amperes.

4-220. +22-V SERIES REGULATOR. Circuit operation of the +22-V series regulator is similar to that of the +12-V series regulator (paragraph 4-216).

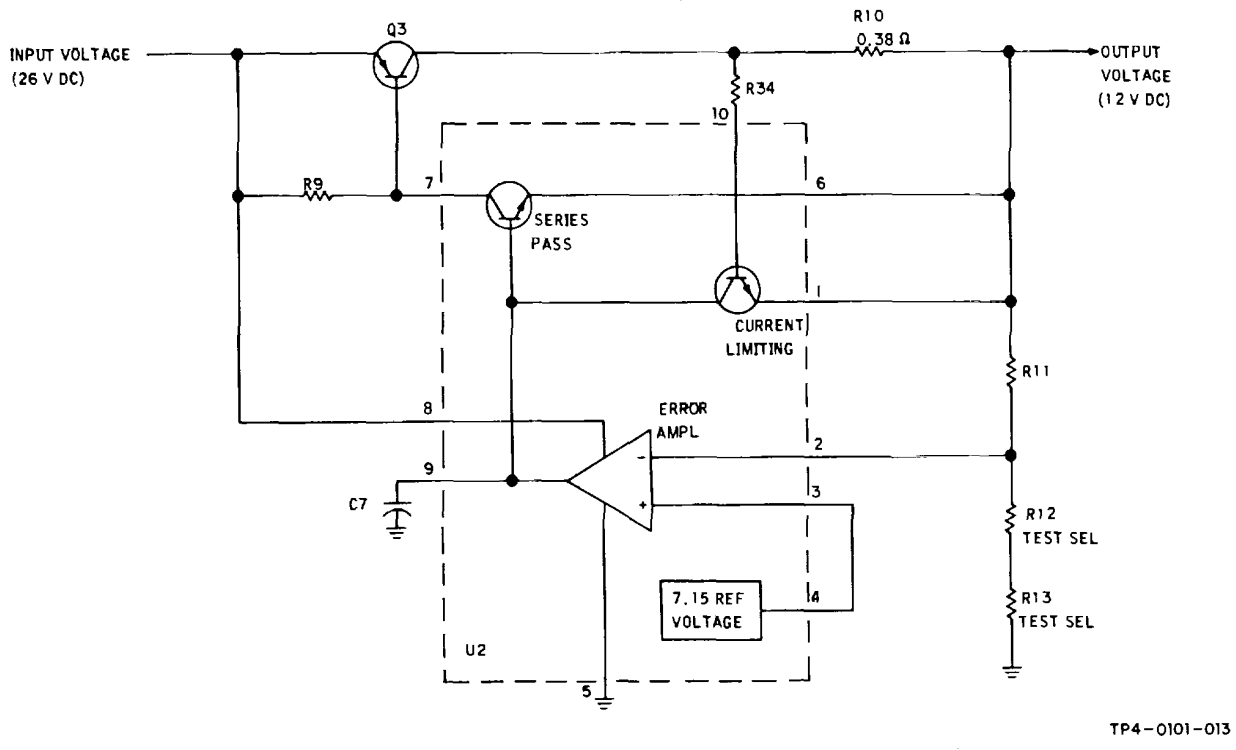

Figure 4-8. +12-V Series Regulator, Simplified Schematic Diagram

Resistor R30 is test selected to set the output voltage to approximately +22 V dc. The output current from the 22-V series regulator is not current limited.

4-221. RF FILTER MODULE A7.

4-222. Refer to the block diagram of figure FO-9 and schematic diagram of figure FO-24 while reading the following circuit descriptions. Unless otherwise specified, reference designators apply to components of rf filter module A7.

4-223. GENERAL. Refer to figure FO-9. Rf filter module A7 contains a transmit/receive switch, rf filter, and directional coupler. The transmit/receive switch consists of three pin diodes (transmit series diode, receive series diode, and receive shunt diode) that together function as a transfer switch and receive signal attenuator. In transmit mode, the transmit series diode provides minimum attenuation to the transmit rf signal while the receive series and receive shunt diodes provide about 36 dB of isolation between the antenna and receiver. In receive mode, the receive series and receive shunt diodes provide from 0- up to about 36-dB attenuation for AGC control and receiver overload protection. The transmit series diode provides about 20 dB of isolation between the antenna and power amplifier.

4-224. The rf filter is a tunable bandpass filter that provides a high degree of selectivity between the antenna and power amplifier or antenna and receiver. The rf filter module includes the rf filter, mechanical drive train, and servo motor with position feedback potentiometer, whereas d/a servo amplifier module A1 provides control to the servo motor to position the rf filter to the desired frequency.

4-225. The directional coupler senses forward and reflected power into the antenna during transmit mode. Outputs from the directional coupler are amplified and fed back to the power amplifier module A8 for automatic load control and to the meter circuit on the front panel of chassis A10. Percent modulation, derived from the forward power output, is fed to the meter circuit.

4-226. TRANSMIT/RECEIVE SWITCH AND CONTROL CIRCUIT. Refer to figure FO-24. Transmit series diode CR1, receive series diode CR2, and receive shunt diode CR3 are pin-type diodes that exhibit the characteristic of providing an increasing rf resistance as the dc current through the diodes decreases. Maximum resistance is attained when the diodes are reverse biased. Minimum resistance is attained when CR1 is forward biased at about 100

milliamperes and CR2 and CR3 at about 10 milli-amperes. The control circuits process rf attenuation (AGC) voltage and key-line voltage to control dc current flow through the diodes. Chokes L1, L2, L3, and L4 isolate the rf path from the dc control circuits.

4-227. In the control circuit, series diode control amplifier U1B and receive attenuator Q4 control dc current flow through receive series diode CR2. The current path is from the 5.1-V dc line (P4-9) through current shaping network R1-R2-R3-CR4-CR5, capacitor C6, choke L2, series receive diode CR2, choke L4, capacitor C9, and receive attenuator Q4 and to ground through receive enable switch Q3. Shunt diode control amplifier U1A controls dc current flow through receive shunt diode CR3. The current path is from the 5.1-V dc line through current shaping network R1-R2-R3-CR4-CR5, capacitor C6, choke L2, receive shunt diode CR3, capacitor C7, and resistor R8 and to ground through U1A. The transmit-to-receive and receive-to-transmit transfer function of the transmit/receive switch is controlled by the combined circuit action of key off delay transistor Q1, transmit enable switch Q2, receive enable switch Q3, and diodes CR8, CR10, and CR16.

4-228. The transfer function of the transmit/receive switch operates as follows. To switch from receive to transmit mode, the logic 0 key 1 voltage (P4-13) turns transistor Q1 off which, in turn, turns transmit enable switch Q2 on. When on, transistor Q2 provides a dc current path to ground for receive shunt diode CR3 and transmit series diode CR1. This forward biases CR3 and CR1 (minimum rf resistance) and causes the rf signal to be shunted to ground through capacitors C7-C2-C16 and C8. Transistor Q2 also shunts to ground base drive to transistor Q3 causing Q3 to turn off. This opens the dc current path through receive attenuator Q4 and allows a voltage of about +75 V dc to be developed across resistor R14 by voltage divider action of resistor R28 and R14. This voltage, when applied through choke L4 to the cathode of receive series diode CR2, reverse biases CR2. The combination of CR2 being reverse biased and CR3 being forward biased provides maximum attenuation to the rf signal between the receiver and antenna ports of the transmit/receive switch. Forward-biased transmit series diode CR1 provides minimum attenuation to the rf signal between the power amplifier and antenna ports.

4-229. To switch from transmit to receive mode, the logic 1 key 1 voltage turns transistor Q1 on which, in turn, turns transmit enable switch Q2 off. Resistors R16, R17, capacitor C15, and diode CR7 provide about 100-microsecond delay to the turn-on time of Q1. This delay assures the power amplifier output power level has dropped completely to zero before series transmit diode CR1 is biased off. When Q2 turns off, base current is supplied to transistor Q3 through resistors R27 and R29. This forward biases Q3 causing it to turn on and enable receive attenuator Q4. The positive voltage (about +25 V dc) developed by voltage divider action of R29, R27, and the base circuit of Q3 reverse biases diode CR8. This enables shunt diode control amplifier U1A. When enabled, U1A and Q4 control receive shunt diode CR3 and receive series diode CR2 respectively. The positive voltage developed by voltage divider action of R29, R27, and the base circuit of Q3 is also applied through resistor R15 to the cathode of transmit series diode CR1. This reverse biases CR1 and causes it to provide maximum attenuation to the rf signal between the transmitter and antenna ports of the transmit/receive switch. Rf attenuation (AGC) voltage determines the rf resistance of the receive series and receive shunt diodes which, in turn, determines the rf signal attenuation between the receiver and antenna ports.

4-230. In receive mode, rf attenuation occurs in stages. Rf attenuation (AGC) voltage (P4-11) from receiver rf module A3 increases in a positive direction as the rf signal strength at the antenna increases. For rf signals that develop an rf attenuation (AGC) voltage of less than 2.5 V dc, the transmit/receive switch provides minimum attenuation to the receive rf signal. As the signal strength increases and the rf attenuation voltage increases above 2.5 V dc, series diode control amplifier U1B and receive attenuator Q4 begin to reduce the current flow through receive series diode CR2 to series attenuate the receive rf signal. At an rf attenuation (AGC) voltage of approximately 4.8 V dc, CR2 reaches maximum signal attenuation. Above 4.8 V dc, shunt diode control amplifier U1A begins to increase the current flow through receive shunt diode CR2 to shunt attenuate the receive signal.

4-231. The following describes circuit action of shunt diode control amplifier U1A, series diode control amplifier U1B, and receive attenuator Q4 as the rf attenuation (AGC) voltage varies from 2.5 to 8 V dc (active range of rf attenuation). Positive 5.1-V dc power supply voltage supplied through resistor R5 to the noninverting input of U1A biases the output of U1A at about 7 V dc when AGC voltage applied through resistor R4 to its inverting input is 0 volt. This reverse biases receive shunt diode CR3. At 2.5-V dc AGC voltage, the output of U1A decreases to about +5.6 V dc which is still sufficient to reverse bias CR3 (minimum shunt rf atten-uation). Series diode control amplifier U1B receives the +2.5-V dc voltage at its inverting input through resistor R9. The voltage at its noninverting input (slightly greater than +2.5 V dc) is a function of the current flow through CR2 and the voltage drop across the current shaping network (R1, R2, R3, CR4, CR5). Under these conditions, the output of U1B is positive which forward biases Q4 on and causes current flow through series diode CR2 (minimum series rf attenuation)

The level of current flow is a function of the current shaping network which allows current to decrease at an exponential rate from about 100 to 0 milliampere as the voltage drop across it varies from 5 to 0 V dc. As the AGC voltage increases above 2.5 V dc, the output of U1B decreases which, in turn, begins to turn receive attenuator Q4 off. This increases the voltage drop across Q4 and reduces the voltage drop across the current shaping network. The result of this circuit action causes the voltage applied to the noninverting input to U1B to increase and track the AGC voltage and at the same time reduces the voltage drop across the current shaping network to reduce current flow through CR2 (increases series rf attenuation). When the AGC voltage reaches about 4.8 V dc (maximum voltage attainable at the noninverting input to U1B), the output of U1B goes negative and turns Q4 off completely. This reduces the current flow through CR2 to about zero. Receive series diode CR2 now provides maximum attenuation to the receive rf signal.

4-232. When AGC voltage exceeds about 4.8 V dc, the output of shunt diode control amplifier U1A decreases below +4.2 V dc and begins to forward bias receive shunt diode CR3 to reduce its rf resistance. As AGC voltage increases to about 8 V dc, the output voltage of U1A decreases which, in turn, increases the voltage across the current shaping network. This allows current through CR3 to increase as the AGC voltage increases. As current through CR3 increases, the rf resistance to ground (through C7) decreases to attenuate the rf signal. When the transmitter is keyed, the rf attenuation voltage goes to about 11 V dc. This causes maximum signal attenuation (receiver muting) to the receive rf module.

4-233. RF FILTER. Rf filter A7A1 (figure FO-24) is a 4-pole, tunable bandpass filter. Under control of d/a servo amplifier module A1, servo motor B1 positions the filter to the center frequency as determined by the radio set control. Position feedback potentiometer R20 feeds position information back to d/a servo amplifier module A1. Balance potentiometers R21 and R22 allow adjustment of the voltage across R20 so that the position feedback voltage tracks the filter position with respect to center frequency.

4-234. The filter provides a bandwidth of ±1.5 MHz from center frequency and maximum insertion loss of about 2 dB within this bandwidth. At ±7 MHz from center frequency, the filter provides more than 40 dB of attenuation; at ±15 MHz from center frequency, the filter provides more than 70 dB of attenuation; and at ±30 MHz from center frequency, the filter provides more than 80 dB of attenuation.

4-235. DIRECTIONAL COUPLER. The directional coupler (A7A2 of figure FO-24) senses forward and reflected power. The forward power sensor consists of variable capacitor C22, capacitors C24 and C26, resistor R31, and detector diode CR12. The reflected power sensor consists of variable capacitor C21, capacitors C23 and C25, resistor R30, and detector diode CR11. Both sensors develop 3.5 to 4 V dc for 20 watts of forward or reflected power.

4-236. FORWARD POWER AMPLIFIER. Forward power amplifier U2A (figure FO-24) amplifies the forward power output of directional coupler A7A2 to provide at its output approximately 4 volts per 20 watts (2 volts per 5 watts) of forward power. The circuit functions as follows. Forward power output from the directional coupler of approximately 2 volts per 20 watts (1 volt per 5 watts) is applied to the noninverting input of U2A through resistors R34 and temperature-compensation network R32-R33. A negative voltage from potentiometer R41 of voltage divider R44-R43-R41 is also applied to the noninverting input of U2A through resistor R39 and temperature-compensation diode CR14. This negative voltage provides forward-biased voltage to direction coupler detector diode CR12 to bias it at the point of conduction (approximately 100 microamperes). To compensate for the negative bias voltage, negative voltage (approximately -0.4 V dc) is developed across resistor R47 of voltage divider R45-R46-R47 and applied to the inverting input of U2A. Potentiometer R41 is adjusted to give zero output voltage from U2A when forward power is 0 watt. Variable resistor R49 controls the gain of U2A and is adjusted to give 4-volt output voltage for 20 watts of forward power. Capacitor C32 in conjunction with resistor R45 and capacitor C27 in conjunction with resistor R44 decouple the bias voltages applied to the forward power amplifier from the -12-V dc line.

4-237. REFLECTED POWER AMPLIFIER. Reflected power amplifier U3 (figure FO-24) amplifies the reflected power output of directional coupler A7A2 to provide at its output approximately 4 volts per 5 watts of reflected power. The circuit functions the same as forward power amplifies U2A except variable resistor R53 is adjusted to give 4-volt output voltage for 5 watts of reflected power. Variable resistor R40 is adjusted to give a slight negative output voltage (about -0.120 V dc) for 0 watt of reflected power. This negative voltage prevents the pa/antenna power comparator circuits in power amplifier module A8 from tripping at small forward power levels or during modulation troughs.

4-238. PERCENT MODULATION MONITOR. The percent modulation monitor (figure FO-24), consisting of amplifier U2B and variable attenuator Q5, processes the forward power output signal from U2A to develop a dc percent modulation output voltage (P4-14) that is proportional to the percent modulation of the transmitted signal. The forward power output signal is composed of an audio component that represents the modulation envelope superimposed on a positive

dc component that represents the average forward power level. Capacitor C33 couples the audio component to peak detector circuit CR15-C34 where the negative peak voltage of the modulation envelope is developed across capacitor C34. The negative voltage is applied to the input of U2B where it is amplified by a voltage gain of about 2.4 V/V (inverting). The output of U2B is applied to a voltage divider consisting of resistor R60 and FET Q5 of the variable attenuator.

4-239. FET Q5 operates in the voltage-controlled resistor mode. Negative voltage developed across potentiometer R59 and applied to the gate of Q5 through R64 biases Q5 to a high resistance. As forward power increases, the positive dc output voltage from U2A is applied to the gate of Q5 through resistor R58. Capacitor C35 filters out the audio component. The positive dc voltage makes the gate voltage less negative to reduce the drain to source resistance of Q5 which increases the attenuation of the output signal from U2B. For a constant modulation percentage, this circuit action compensates for the increase in peak-to-peak amplitude of the modulation envelope as the power level increases. The result is a nearly constant voltage applied across R61 and the meter circuit of chassis A10 to indicate the percent modulation.

4-240. Potentiometer R59 allows calibration of the percent modulation monitor.

4-241. POWER AMPLIFIER MODULE A8.

4-242. Power amplifier module A8 consists of seven subassemblies A8A1 through A8A7 and a chassis (finned heat sink). Each subassembly has an individual schematic diagram (figures FO-26 through FO- 31) and the chassis (A8) an interconnect diagram (figure FO-25) that ties all the subassemblies together. A block diagram of the overall rf power amplifier module is shown in figure FO-10.

4-243. GENERAL. Refer to figure FO-10. The transmit rf signal (+12 to +16 dB mW) from the synthesizer module to be transmitted is applied to the resistive tee attenuator of rf preamplifier/modulator ABA2. The resistive tee attenuator compensates for gain variations in the three rf amplifiers of A8A2. The amount of attenuation is determined through a test select process to provide about 0.3- watt carrier level output from A8A2 for +14-dB mW input.

4-244. The transmit audio signal from the audio module to be transmitted is applied to the modulator of ALC/modulator A8A1. The modulator amplifies the transmit audio signal to provide a modulation base drive signal to the modulation transistor that controls power supply voltage applied to the high-level modulated rf amplifiers. The modulation transistor varies the supply voltage in accordance with audio content of the transmit audio signal which, in turn, varies the gain of the high-level modulated rf amplifiers to amplitude modulate the transmit rf signal. Modulation feedback from the modulation transistor and envelope feedback taken from the power amplifier forward power signal are fed back as negative feedback to control ac gain of the modulator and to reduce distortion in the transmitted rf signal.

4-245. The output rf signal from rf preamplifier/ modulator A8A2 is applied to the pin diode ALC attenuator of rf predriver/ALC attenuator A8A3. Under the control of ALC voltage, the pin diode ALC attenuator varies circuit gain to maintain a constant forward power output from the receiver-transmitter. ALC voltage is developed from the ALC circuit which consists of an inner (secondary) control loop and outer (primary) control loop. In the secondary control loop, power amplifier forward power from reflectometer A8A7 is processed by the ALC amplifiers. In the primary control loop, antenna forward power from the rf filter module is processed. Under normal circuit conditions, the primary control loop controls the power output from the receiver- transmitter. Variations in the antenna forward power signal caused by changes in loading will cause the ALC voltage to affect the pin diode ALC attenuator in such a manner as to counteract the variations to maintain a constant power output. The rf output signal of the pin diode ALC attenuator is amplified by the two linear rf amplifiers and applied to rf driver A8A4.

4-246. The output signal from rf predriver/ALC attenuator A8A3 Is applied to the gain slope pad of rf driver A8A4. The gain slope pad provides frequency-versus-gain compensation for the rf power amplifier module. The output of the gain slope pad is amplified by the rf amplifier (no 6) to provide about 12-watt output carrier level.

4-247. The output signal from rf driver A8A4 is applied to the 3-dB, 90-degree hybrid coupling circuit (A8HY1) where the signal is split into two signals. Each signal is then applied to a 3-dB, 90-degree hybrid coupler in each of the amplifiers, A8A5 and A8A6, where each signal is again split into two signals. Through the two tiers of hybrid couplers, the rf signal is applied to four broadband rf amplifiers that are isolated from one another and operate in parallel to share one-fourth the load. The rf signals are amplified by the four rf amplifiers and combined into one rf signal by two tiers of 3-dB, 90-degree hybrid couplers to produce about 30-watt carrier level at the output of hybrid A8HY2.

4-248. The output signal from hybrid A8HY2 is applied to reflectometer A8A7 where the level of power amplifier forward power and reflected power is detected and applied to ALC/modulator A8A1. The rf output signal from the reflectometer is applied to the rf filter module.

4-249. ALC/modulator A8A1 includes a monitor circuit that reduces the power amplifier rf output to about 4 watts if a high heat-sink temperature, high vswr, or high rf filter insertion loss is detected. The monitor circuit consists of antenna vswr comparator, pa/antenna power comparator, and the overtemperature detector. The antenna vswr comparator compares antenna reflected power to antenna forward power to activate the pa power turndown switch (via the OR gate) if the antenna vswr exceeds about 3 to 1. The pa/antenna power comparator compares pa forward power to antenna forward power to activate the pa power turndown switch if the pa to antenna power ratio exceeds about 2 dB. The overtemperature detector activates the pa power turndown switch if the heat-sink temperature at the rf amplifier transistors exceeds 100 degrees Celsius. When activated, the pa power turndown switch reduces the pa power output reference voltage. The reference voltage is compared to the pa and antenna forward power signals to develop the ALC voltage. When the reference voltage decreases, the ALC voltage increases. This causes the pin diode ALC attenuator to attenuate the transmit rf signal by about 7 dB. The one-shot stretches momentary vswr faults into a greater than 300-millisecond activating signal to the pa power turn-down switch. For momentary faults, this allows the ALC control loop to stabilize at low power before returning to normal power.

4-250. The transmitter keying control (key 2) is applied to the pa turndown switch, receive mode shutdown switch, and ALC precharge amplifier of ALC/modulator A1. When the transmitter is unkeyed, the receive mode shutdown switch causes the ALC amplifiers to apply maximum ALC voltage to the pin diode ALC attenuator. This provides maximum rf signal attenuation during receive mode. In addition, the power amplifier turndown switch removes bias (+5 V dc switched) voltage from the predriver amplifier causing the power output of the rf predriver/ALC attenuator, A8A3, to go to 0 watt. This turns off the power amplifier during receive mode.

4-251. When the transmitter is unkeyed, the ALC precharge amplifier applies a voltage to the ALC amplifiers that represents an antenna forward power slightly above the normal power output from the transmitter. The time constant control circuit allows this to occur in minimum time. The ALC precharge voltage preconditions the ALC circuit so that when the transmitter is again keyed, the ALC circuit will be turning the power output down at the same time as the power output is coming up. The combination of this circuit action results in the transmitter going to full power output with no overshoot and in minimum key-on time (about 120 milliseconds).

4-252. The following is a detailed description of the individual subassemblies of the rf power amplifier module.

4-253. RF PREAMPLIFIER/MODULATOR A8A2. Refer to figure FO-27. The transmit rf input signal is coupled to the stage 1 class A rf amplifier, Q1, through the resistive tee attenuator composed of resistors R1, R2, and R3 and through the impedance matching network composed of inductors L1 and L2; capacitors C1, C2, and C3; and resistor R4. Resistors R1, R2, and R3 are test selected to provide proper input impedance (50 ohms) and input signal attenuation so that the rf output from A2 is about 0.3-watt carrier power for a +14-dB mW transmit rf input signal. Transistor Q1 is biased to about 30-milliampere collector current by base current supplied from bias transistor Q4. Transistor Q4 controls base current to Q1 by comparing a reference voltage developed across resistor R6 and diode CR1 of voltage divider R6-CR1-FL2-R7 to the voltage developed across resistor R8 which is a function of base current and collector current of Q1. Diode CR1 provides temperature compensation for Q1.

4-254. The amplified output of Q1 is coupled to the stage 2 high-level modulated rf amplifier, Q2, through the impedance matching network composed of inductors L3 and L4 and capacitors C4, C5, and C6. Transistor Q2 is biased by base current supplied from bias network R10-CR2-FL5 and applied to the base of Q2 through resistor R9. Resistor R10 is test selected to produce a reference voltage across diode CR2 that biases Q2 to about 13-milliampere collector current. Diode CR2 provides temperature compensation for Q2.

4-255. The amplified output of Q2 is coupled to the stage 3 high-level modulated rf amplifier, Q3, through the impedance matching network composed of induc- tors L5, L6, and L7; capacitors C7, C9, C10, and C11; and resistor R11. Transistor Q3 is biased by base current supplied from bias network R13-CR3-C12 and applied to the base of Q3 through resistor R12. Resistor R13 is test selected to produce a reference voltage across diode CR3 that biases Q3 to about 12-milliampere collector current. Diode CR2 provides temperature compensation for Q3.

4-256. The amplified output of Q3 is coupled to the output of A2 through the impedance matching network composed of inductors L8, L9, and L10; capacitor C13; and resistor R15.

4-257. Refer to paragraph 4-270 for a discussion of the modulation of transistors A8A2Q2 and A8A2Q3.

4-258. RF PREDRIVER/ALC ATTENUATOR A8A3. Refer to figure FO-28. Capacitor C1 couples the input rf signal to the pin diode ALC attenuator where the signal is attenuated in accordance with the level of applied ALC voltage. To understand the operation of the pin diode ALC attenuator, consider the operation of hybrid couplers in general. Hybrid couplers used in this equipment consist of four terminal devices containing two coupled, quarter wavelength lines

cut to the center of the uhf operating frequency. Refer to A8HY1 and A8HY2 of figure FO-25. When terminals E2, E3, and E4 of A8HY1 are terminated into 50 ohms (characteristic impedance of the quarter wavelength lines), the input rf signal applied to terminal E1 divides equally and appears at output terminals E3 and E4, 3 dB down (half power) and 90-degree phase related. No signal appears at terminal E2. The isolation between output terminals is approximately 25 dB. When two rf signals are simultaneously applied to terminals E3 and E4, the signals add together and appear at either terminal E1 or terminal E2 depending upon the 90-degree phase relationship of the input signals. In the case of A8HY2 of figure FO-25, the rf signals add at terminal E1 and cancel at terminal E2. If the loading at terminals E3 and E4 of A8HY1 becomes greater than 50 ohms, the reflected power that results from the mismatch adds together and appears at terminal E2. This reduces the power output at terminals E3 and E4 and increases the power at terminal E2. The hybrid coupler used in the pin diode ALC attenuator of figure FO-28 uses this principle to attenuate the input rf signal.

4-259. Refer to figure FO-28. ALC voltage applied through rf chokes L1 and L2 to the anode of pin diodes CR1 and CR2 causes the resistance to ground at terminals E3 and E4 of HY1 to vary as a function of the ALC voltage. When the ALC voltage is a high positive value, the resistance of CR1 and CR2 is low causing the resistance to ground at terminals E3 and E4 to be approximately 50 ohms (R2 in parallel with R3 and R4 in parallel with R5). For this condition, the pin diode ALC attenuator provides maximum signal attenuation since almost all the rf input signal applied to terminal E1 appears across resistors R2, R3, R4, and R5 and very little appears at terminal E2. The rf signal that does appear at terminal E2 is shunted to ground through pin diode CR3 and capacitor C4. Pin diode CR3 offers minimum resistance because of ALC voltage applied through HY1 from terminal E4 to terminal E2. As the ALC voltage decreases toward zero and becomes negative, the resistance of CR1, CR2, and CR3 increases causing the resistance to ground at terminals E2, E3, and E4 to increase. As the resistance increases from 50 ohms, the increase in reflected power resulting from the mismatch appears at terminal E2. Thus, as the ALC voltage decreases, the attenuation of the pin diode ALC attenuator decreases causing the signal at terminal E2 to increase. This signal is applied to the base of transistor Q1 of the stage 4 linear rf amplifier through the impedance matching network composed of capaci-tors C5, C6, C7, C8, and C9; inductors L3 and L4; and resistor R7.

4-260. Transistor Q1 is biased by base current supplied from bias network R11-R9-RT12-CR4 and applied to the base of Q1 through resistor R8 and impedance network Z1 (ferrite beads). Resistor R9 is test selected to produce a reference voltage across diode CR4 that biases Q1 to about 20 milliamperes. Thermistor RT12 provides temperature compensation for the stage 4 linear rf amplifier.

4-261. The amplified output of Q1 is coupled to the stage 5 linear rf amplifier, Q2, through the impedance matching network composed of capacitors C17, C18, and C19, inductor L5, and resistors R18 and R19. Transistor Q2 is biased by base current supplied from bias network R13-R10-RT14-CR5 and applied to the base of Q2 through inductor L7 and impedance network Z2 (ferrite beads). Resistor R10 is test selected to produce a reference voltage across diode CR5 that biases Q2 to about 20 milliamperes. Thermistor RT14 provides temperature compensation for the stage 5 linear rf amplifier. The amplified output of Q2 is coupled to the output of A3 through the impedance matching network composed of inductors L8, L9, and L10 and capacitors C20, C21, C22, C25, and C26.

4-262. When the transmitter is unkeyed, the voltage applied to the +5-V dc switched input is reduced to 0 V dc and the applied ALC voltage is increased to a high positive value. This removes the bias voltage from Q1 and Q2 and causes maximum signal attenuation by the pin diode ALC attenuator. The result of this circuit action is to provide maximum attenuation in the rf signal path through A8A3.

4-263. RF DRIVER A8A4. Refer to figure FO-29. The rf input signal is coupled to the broadband rf power amplifier, Q1, through the gain slope pad composed of inductors L1 and L2, resistors R1, R2, and R3, and capacitor C1. The gain slope pad compensates for loss in power amplifier gain as the frequency of the applied rf input signal increases. The pad loss is about -5 dB at 225 MHz, -2 dB at 300 MHz, and -0.5 dB at 399 MHz. Rf power amplifier Q1 amplifies the rf signal to approximately 12-watt carrier power. Refer to paragraph 4-266 for a description of the rf amplifier.

4-264. RF AMPLIFIERS A8A5 AND A8A6. Refer to figure FO-30. The rf input signal is applied to terminal E2 of hybrid HY1. HY1 splits the signal into two separate signals that are 3 dB down from the input signal and 90-degree phase related and applies them to two broadband rf amplifiers, Q1 and Q2. The amplified outputs of Q1 and Q2 are applied to terminals E3 and E4, respectively, of hybrid HY2 where they are shifted back into phase and coupled to the rf output at terminal E2. Refer to paragraph 4-266 for a description of the rf amplifiers.

4-265. Refer to figures FO-25 and FO-30. Isolation resistors A8R3 and A8R5 connected to rf amplifier A8A5 dissipate any reflected power that may result from impedance unbalance at the input or output of

rf amplifiers A8A5Q1 or A8A5Q2. In a like manner, isolation resistors A8R2 and A8R6 dissipate reflected power from rf amplifiers A8A6Q1 or A8A6Q2.

4-266. RF AMPLIFIERS A8A4Q1, ASA5Q1/Q2, A8A6Q1/Q2. The rf amplifier (A8A4Q1 of figure FO-29) of rf driver A8A4 and the rf amplifier pair (A8A5Q1/Q2 and A8A6Q1/Q2 of figure FO-30) of rf amplifiers A8A5 and A8A6 are all identical. Therefore, only rf amplifier ASA5Q1 of figure FO-30 will be discussed in detail. Transistors Q1 and Q2 or rf amplifiers A8A5 and A8A6 are a matched quad so that the gain through each of the four parallel paths is identical.

4-267. Refer to figure FO-30. The output of hybrid HY1 is coupled to the base of rf amplifier transistor Q1 through the impedance matching network composed of inductors L1 and L11 and capacitors C1, C2, C3, and C4. Transistor Q1 is biased by a reference voltage developed across diode CR1 of bias network CR1-R2-C1 and applied to the base of Q1 through resistor R1. The amplified output of Q1 is coupled to hybrid HY2 through the impedance matching network composed of inductors L12, L4, L3, and L5 and capacitors C5 through C9. Capacitors C12, C13, and C10 and inductor L2 decouple the rf amplifier from the +26-V dc line. The amplifier power gain is approximately 8 dB.

4-268. REFLECTOMETER A8A7. Refer to figure FO-31. The reflectometer senses forward and reflected power at the output of the power amplifier module. The forward power sensor consists of resistor R2, capacitors C1 and C3, and detector diode CR1. The reflected power sensor consists of resistor R1, capacitors C2 and C4, and detector diode CR2. Both sensors develop approximately 1 volt for 20 watts (0.5 volt at 5 watts) of forward or reflected power.

4-269. ALC/MODULATOR A8A1. ALC/modulator A8A1 contains the modulator circuit, ALC circuit, antenna vswr monitor, pa/antenna power monitor, and the temperature monitor.

4-270. Modulator Circuit. Refer to figures 4-9, FO-25, FO-26, and FO-27. With no transmit audio applied, modulation amplifier A8A1U1 sets the quiescent modulation input voltage applied to rf preamplifier/ modulator A8A2 at about 6 V dc. In A8A2, this voltage is applied as collector voltage to the high-level modulated rf amplifiers, A8A2Q2 and A8A2Q3. To set the quiescent modulation input level, modulation amplifier ASA1U1 compares a reference voltage to a modulation feedback voltage (P1-5) to control base drive to modulation transistor A8Q1. The reference voltage developed across resistor A8A1R6 of voltage divider A8A1R5-R6 is applied to the noninverting input of ASA1U1. The feedback voltage developed at the arm of potentiometer A8A1R11 of voltage divider A8A1R8-R11-R12 is applied through resistor A8A1R10 to the inverting input of A8A1U1. A8A1U1 amplifies the differential input voltage to develop the base drive signal to A8Q1. Potentiometer A8A1R11 is adjusted to set the collector voltage of A8Q1 to about 6 V dc.

4-271. When transmit audio is applied, capacitor A8A1C3 couples the audio signal to the noninverting input of A8A1U1. The audio signal, when amplified by A8A1U1, causes the collector voltage of A8Q1 to vary at the audio rate which, in turn, causes the collector voltage of A8A2Q2 and A8A2Q3 to vary at the audio rate. By varying the collector voltage, the gain of A8A2Q2 and A8A2Q3 is modulated at the audio rate which causes the transmit rf signal to be amplitude modulated.

4-272. Ac gain of the modulator is controlled by negative feedback of the modulation signal applied to the inverting input of ABA1U1. The ac component of the modulation feedback signal (P1-5) is applied to the inverting input of A8A1U1 through voltage divider A8A1R7-R15, resistor A8A1R9, and capacitor A8A1C9
Capacitor A8A1C7 provides an ac ground for resistor A8A1R10. The ac component of the pa forward power signal detected at reflectometer A8A7 and amplified by A8A1U3A is fed back as envelope feedback to the inverting input of A8A1U1 through voltage divider A8A1R19-R20, (A8A1R20 grounded through A8A1U2D), resistor A8A1R18, and capacitor A8A1C9. When a vswr, pa/antenna power, or temperature fault is detected, the envelope feedback control switch, A8A1U2F and A8A1U2D, opens the ground circuit to resistor A8A1R20 to increase the level of the envelope feedback signal. The ac gain of the modulator circuit is such that approximately 0.85 volt of transmit audio modulates the transmit rf signal to 90 percent. Envelope feedback improves the audio quality (reduces distortion) of the transmitted audio signal.

4-273. ALC Circuit. Refer to figure FO-26. Reference designators apply to A8A1. The ALC circuit consists of the following circuits of ALC/modulator A8A1: pa forward power amplifier U3A, buffer U7A, ALC differential amplifier U6B, ALC differential amplifier U4A, ALC output amplifier Q3-Q4, pa power output reference source U6A, ALC precharge amplifier U4B-Q5, and time constant control Q1-Q6-Q7. In the primary control loop, the ALC circuit receives the antenna forward power signal (P1-1) from the rf filter module and provides ALC voltage (P1-11) to the pin diode ALC attenuator of rf predriver/ALC attenuator A8A3 to control power output at the antenna. In the secondary control loop, the ALC circuit receives the pa forward power signal (P1-6) from reflectometer A8A7 and provides ALC voltage (P1-11) to the pin diode ALC attenuator (A8A2) to control power output from the rf power amplifier module. The secondary control loop takes over control if, for some reason, the rf filter module fails to provide power to the antenna or has a high insertion loss. The ALC circuit functions as follows.

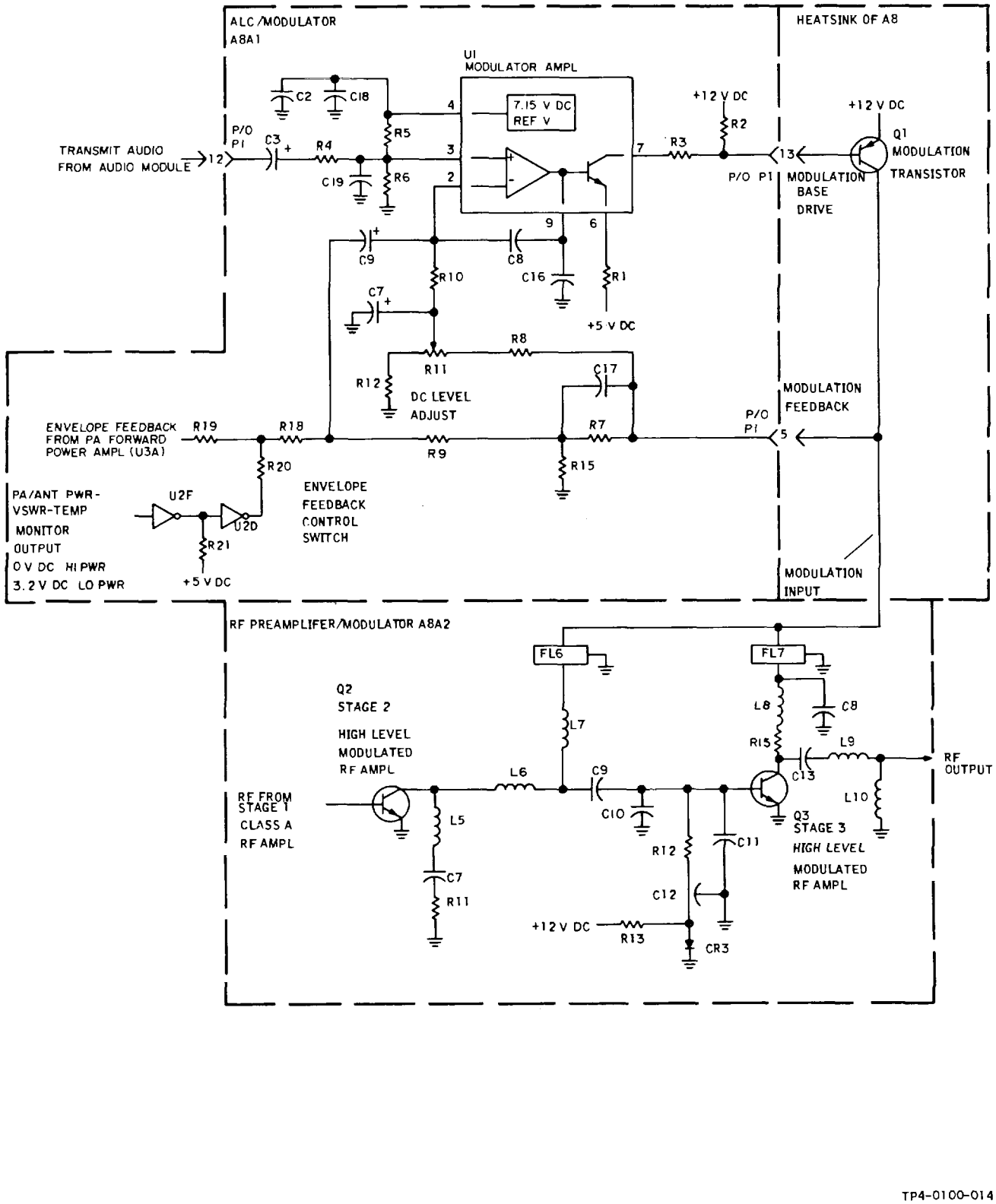

Figure 4-9. Power Amplifier Modulator, Simplified Schematic Diagram

4-274. The pa power output reference source, U6A, amplifies (by unity gain) a portion of the reference voltage from U1 applied across voltage divider R56-R57-R58 to produce the pa power output reference voltage. This reference voltage, as set by potentio-meter R57, determines the power output from the receiver-transmitter.

4-275. In the primary ALC control loop, when the transmitter is keyed (logic 0 key 2 voltage), the ALC differential amplifier, U6B, compares the antenna forward power signal applied to its noninverting input through low-pass filter C13-R41 to the pa power output reference voltage applied to its inverting input through resistor R62. Low-pass filter C13-R41 removes modulation from the antenna forward power signal. The amplified difference signal at the output of U6B is applied to the noninverting input of U4A through resistor R64.

4-276. In the circuit of U6B, diode CR7 prevents the output from going negative by more than about -0.6 V dc. Capacitor C12 in parallel with resistor R63 in conjunction with U6 forms an active low-pass filter to remove modulation. Diode CR8 provides temperature stability. During transmit mode, the ALC precharge amplifier, U4B-Q5, and time constant control Q1-Q6-Q7, have no effect on the output of U6B, since the logic 0 key 2 voltage causes Q5 to be turned off and FET's Q6 and Q7 to be biased at maximum resistance.

4-277. In the secondary ALC control loop, the pa forward power amplifier, U3A, amplifies the pa forward power signal and applies the result to the noninverting input of U4A through low-pass filter C10-R44, voltage divider R45-R53, buffer U7, and isolation diode CR12. Resistor R67 in the circuit of U3A is test selected to adjust the gain of U3A to compensate for level variations in pa forward power that exist between different reflectometer, A8A7, subassemblies. Low-pass filter C10-R44 removes modulation from the pa forward power signal. Under normal circuit conditions, the output voltage from U6B is greater than the output of U7, therefore, making it the primary controlling signal. Diode CR12 isolates the two control loops so that they do not interfere with each other.

4-278. ALC differential amplifier U4A compares the voltage from either U6B or U7 applied to its noninverting input to the pa power output reference voltage applied through resistor R74 to its inverting input. The amplified difference voltage from U4A drives the ALC output amplifier, Q3-Q4, to produce the ALC voltage.

4-279. As a result of the above circuit action, ALC voltage applied to the pin diode ALC attenuator is a function of both the pa power output reference voltage and either the antenna forward power or pa forward power. By adjusting potentiometer R57, the ALC voltage (via the pa power output reference voltage) can be varied to set the receiver-transmitter power output to the desired rf level. To maintain a constant power output from the receiver-transmitter, variations in power output appear as variations in the forward power signal. These variations, when compared to the pa power output reference voltage, cause the ALC voltage to change in such a direction to counteract the power output variations.

4-280. If a vswr, pa/antenna power, or temperature fault is detected, the ALC voltage is increased to reduce the power output to approximately 4 watts. This is accomplished by the following circuit action: When a fault is detected, the pa power turndown switch, U2A, connects resistor R59 to ground in parallel with potentiometer R57 and resistor R58. This decreases the voltage applied to the pa power output reference source (U6A) by about 7 dB which, in turn, causes the output of U6A to decrease by the same amount. The decrease in pa power output reference voltage causes an increase in the differential input voltage at the input of U4A. This increase in voltage, when amplified by the ALC differential amplifier, U4A, and ALC output amplifier, Q3-Q4, causes the ALC voltage to go to a high positive value to reduce the power output of the receiver-transmitter to 0 watt. As a result of this, the antenna forward power and pa forward power go to zero, but because of the antenna forward power voltage stored in capacitor C13 and the lag in the output of U6B, the reduction in reference voltage applied to U6B does not cause an instantaneous increase in its output voltage. The resulting voltage at the output of U6B, when applied to U4A, holds the ALC voltage at a high positive value until the charge across capacitor C13 discharges. As the charge across C13 decreases, the output of U6B decreases which, in turn, causes the ALC voltage to decrease. After a period of time, power again appears at the antenna, but because of the reduction in the pa power output reference voltage, the new power output level is approximately 4 watts.

4-281. When the fault is cleared, the pa power turn-down switch, U2A, removes resistor R59 from ground and allows capacitor C11 to charge. The RC time constant of R59 and C11 determines the rise time of the pa power output reference voltage which, in turn, determines the power up time of the power amplifier module to the normal power output level.

4-282. When the receiver-transmitter is unkeyed, the logic 1 key 2 voltage (P1-9) causes the following circuit actions to occur to turn off the rf power amplifier and to precondition the ALC circuit.

4-283. Logic 1 key 2 voltage applied to U2E of the pa turndown switch causes transistor Q2 to turn off. When Q2 turns off, +5 V dc is removed from the +5 V dc switched output (P1-2) and from the antenna vswr and pa/antenna power comparators (U5A, U5B).

When the +5-V dc switched voltage goes to 0 volt, bias voltage is removed from the linear rf amplifiers of the rf predriver/ALC attenuator, A8A3. Removing +5 V dc from U5A and U5B causes the output of the antenna vswr and pa/antenna power comparators to remain low, independent of their inputs.

4-284. Logic 1 key 2 voltage applied to the base of time constant control transistor Q1 through resistor R85 causes Q1 to turn on. When Q1 turns on, the +12-V dc gate voltage that biased FET's Q6 and Q7 off is shunted to ground causing Q6 and Q7 to turn on. When on, Q6 provides a low resistance path in parallel with resistor R63 and capacitor C12 (fast discharge path for C12). When on, Q7 provides a low resistance path across resistor R62. Together, the low resistance of Q6 and Q7 changes the gain and time constant characteristics of the ALC differential amplifier, U6B.

4-285. The logic 1 key 2 voltage applied to the cathode of CR18 of the ALC precharge amplifier (U4B-Q5) reverse biases CR18 and allows the pa power output reference voltage to be applied to the noninverting input (through R87) of U4B. This causes the output of U4B to go positive, turn on Q5, and apply a positive voltage to the noninverting input of U6B. ALC differential amplifier U6B compares the output of Q5 to the pa power output reference voltage and develops an output voltage that applied to the voltage divider formed by resistors R64, R69, and R72. The voltage across R72 is applied through resistor R55 to the inverting input of U4B. The closed-loop gain of U4B, Q5, U6B, and the voltage divider (R64-R69-R72) is such that the final voltage (precharge voltage) at the noninverting input of U6B is just slightly above the level present when the receiver-transmitter is keyed. The precharge voltage represents a forward power slightly above the normal forward power output from the power amplifier. When the receiver-transmitter is keyed, the ALC circuit takes the precharge voltage as being the antenna forward power output even through the actual antenna forward power output is zero at that instance. The ALC circuit processes the precharge voltage to develop an ALC voltage that causes the pin diode ALC attenuator to reduce the power output at the same time as the rf power amplifier is turning on. The net result of this circuit action is to bring the power output up in minimum key-on time (120 milliseconds) and very little overshoot. The logic 1 key 2 voltage applied to the receive mode pa shutdown switch, U2C, causes resistor R50 to be connected to ground through U2C to increase the gain of U4A-Q3- Q4. When this occurs, U4A amplifies the positive output voltage from U6B and drives the ALC voltage at the output of the ALC output amplifiers, Q3-Q4, to a high positive value. This voltage, when applied to the pin diode ALC attenuator, causes maximum attenuation in the transmit rf signal path of the rf predriver/ALC attenuator, A8A3.

4-286. Antenna VSWR and PA/Antenna Power Temperature Monitor. Refer to figure FO-26. The antenna vswr comparator, U5A, detects antenna voltage standing-wave ratios that exceed about 3 to 1. Voltage developed across resistor R24 of voltage divider R17-R30-R24 sets a positive reference voltage at the inverting input of U5A that is a function of the antenna forward power voltage (about 4 volts at 20 watts). Voltage developed across resistor R32 of voltage divider R31-R43-R32 and applied to the noninverting input of U5A is a function of the antenna reflected power voltage (about 4 volts at 5 watts). Whenever the antenna vswr exceeds about 3 to 1, the reflected power voltage across R32 increases above the forward power reference voltage across R24. This causes the output of U5A to go from low to high whenever the vswr exceeds 3 to 1. Resistor R33 provides positive feedback (hysteresis) to the circuit. This prevents the antenna vswr comparators from tripping more than once whenever the vswr is at the trip threshold. Resistor-capacitor networks R31-C15 and R17-C14 form low-pass filters to filter out high-frequency interference (radar pulses) conducted into the circuit from the antenna. When the antenna forward and reflected power outputs are both zero, positive voltage (+12 V dc applied through voltage divider R16-R17-R30-R24) applied to the inverting input of U5A holds the output of U5A low.

4-287. The pa,/antenna power comparator, U5B, detects pa to antenna power ratios that exceed about 2 dB. Voltage developed across resistor R66 of voltage divider R34-R66 sets a positive reference voltage at the noninverting input of U5B that is a function of the pa forward power voltage (approximately 1 volt at 20 watts). Voltage developed across resistor R40 of voltage divider R39-R40 and applied to the inverting input of U5B is a function of the antenna forward power voltage (approximately 4 volts at 20 watts). Resistor R66 is test selected so that whenever the pa power output exceeds the antenna forward power by more than about 2 dB, the pa forward power voltage across R66 just exceeds the antenna forward power reference voltage across R40. This causes the output of U5B to go from low to high whenever the antenna power decreases such that pa power output exceeds the antenna power by more than 2 dB. Resistor R35 provides positive feedback (hysteresis) to the circuit. This prevents the pa/antenna power comparator from tripping more than once whenever the pa/antenna power ratio is at the trip threshold. When the pa and antenna forward power voltages are both zero, negative voltage (-12 V dc applied through voltage divider R65-R66) applied to the noninverting input of U5B holds the output of U5B to low.

4-288. The overtemperature detector, U7B, detects power amplifier heat-sink temperatures that exceed about 100 degrees Celsius. Thermistor A8RT1 (figure FO-25) connected from P1-14 to ground forms a voltage divider with resistor R78. For low heat-sink

temperatures, the negative voltage developed across A8RT1 and applied to the noninverting input of U7B is more negative than the voltage developed across resistor R79 and applied to the inverting input of U7B. This causes the output of U7B to be negative. As the temperature increases, the resistance of A8RT1 decreases causing the voltage across it to decrease also. When the heat-sink temperature at the rf amplifier transistors exceeds about 100 degrees Celsius, the voltage across A8RT1 becomes less negative than the voltage applied to the inverting input of U7B. This causes the output of U7B to go positive (approximately 10 V dc). To prevent the detector from tripping more than once at threshold, resistive divider R75-R76 applies a positive voltage through resistor R77 to the noninverting input of U7B. This provides hysteresis so that the temperature has to decrease by a certain amount before the voltage across A8RT1 becomes more negative than the voltage applied to the inverting input of U7B.

4-289. When an antenna vswr fault, or pa/antenna power fault, or a heat-sink temperature of over 100 degrees Celsius is detected, the voltage at the cathodes of diodes CR2 and CR3 goes to a positive level. This causes the output of the pa power turndown switch, U2A, to be low (ground) to reduce the power output from the rf power amplifier module. Otherwise, for no fault, the voltage at the cathodes of CR2 and CR3 is about 0 V dc. This causes the output of U2A to be high (open) for normal power output.

4-290. Refer to paragraph 4-272 for a description of the envelope feedback control switch, U2F-U2D.

4-291. The one-shot, U3B, stretches a momentary antenna vswr fault or pa/antenna power fault into approximately a 300-millisecond pulse. When a momentary fault is detected, the output of U2A goes to ground. This allows capacitor C5 to discharge to ground through U2A and develop a negative voltage across resistor R25. When applied to the inverting input of U3B, the negative voltage causes the output of U3B to go high (about 10 V dc) and develop a positive voltage (about 2.3 V dc) across resistor R29 of voltage divider R28-R29. Diode CR1 applies the positive voltage to the input of U2A to hold the output of U2A at ground. At the same time, capacitor C4 begins to charge toward the voltage across R29. The positive voltage developed across resistor R23 as C4 charges holds the output of U3B high as long as the voltage exceeds an approximate +0.54-V dc bias voltage developed across resistor R25 of voltage divider R26-R25. The RC time constant of C4 and R23 determines the length of time the output of U3B is held high

4-292. KEYER MODULE A9.

4-293. GENERAL. Refer to figure FO-32. The keyer module is composed of a squelch operated relay circuit and a transmitter keyer circuit. The squelch operated relay circuit provides a set of spdt relay contacts at the receiver-transmitter input/output connector J22 for use external to the AN/GRC-171. The squelch relay is activated whenever the receiver is not muted by squelch or when squelch is turned off. Keying the transmitter inhibits the squelch relay from being activated.

4-294. The keyer circuit provides interface between the transmitter key line and external audio loop, current loop, or voltage loop type push-to-talk or keying circuits. For audio loop keying, the transmitter can be keyed by a 300- to 3000-Hz tone at a level of -10 to 0 dB mW. An optional jumper on keyer module A9 provides for voice operated keying (VOX) through the audio loop. For current loop keying, the transmitter can be keyed by a 20- to 60-milliampere dc current loop. For voltage loop keying, the transmitter can be keyed by external push-to-talk or keying circuits that employ 6-, or optional 26-, 28-, or 100-V dc keying voltages. Strapping options on keyer module A9 allow for selection of one of the voltage levels.

4-295. SQUELCH OPERATED RELAY CIRCUIT. Refer to figures 4-7 and FO-32. Squelch comparator A9U1 compares the voltage applied to the squelch on/ off line to a bias voltage (about -0.26 V dc) developed across resistor A9R2 of voltage divider A9R1-A9R2. The voltage applied to the squelch on/off input is dependent upon the squelch mode of the receiver which can be one of the following: squelch off, squelch on and the rf input signal level to the receiver below the squelch threshold, or squelch on and the rf input signal above the squelch threshold. With squelch off (ground applied to the squelch on/off input), the bias applied to the inverting input of A9U1 causes the output of A9U1 to be positive (about +3.2 V dc). The positive voltage turns squelch relay driver transistor A9Q1 on to energize squelch relay A9K1.

4-296. With the squelch turned on and an rf receive signal level above the squelch threshold as set by squelch potentiometer A10A1R4, the output of squelch control A4U5B is a positive dc voltage of approximately 10 V dc. (Refer to paragraph 4-175 for a discussion of the squelch control circuit.) This positive voltage is applied through A4R78 and A9R3 to the noninverting input to A9U1 causing the output of A9U1 to be positive to energize relay A9K1. Diode A9CR1 limits the positive voltage applied to the input of A9U1 to about 0.7 V dc.

4-297. Under the above conditions with relay A9K1 energized, keying the transmitter applies a ground (key 1 input) through diode A9CR4 to the base of A9Q1. The ground turns A9Q1 off to deenergize A1K1 whenever the transmitter is keyed. Diode A9CR5 biases the emitter of A9Q1 one diode drop above ground to ensure A9Q1 will turn off when a ground is applied to key 1 input.

4-298. With the squelch turned on and the rf receiver signal level below the squelch threshold, the output of A4U5B is a negative dc voltage of approximately -10 V dc. This negative voltage is applied through resistors A4R78 and A9R3 to the non-inverting input of A9U1 causing the output of A9U1 to be negative (about -0.6 V dc). The negative voltage turns A9Q1 off to de-energize A9K1.

4-299. KEYER CIRCUIT. Refer to figure FO-32. Three resistive divider networks attenuate the three loop input signals and apply the attenuated signals to keyer comparator U2. Under normal use, only one loop is employed at any one time. Keyer comparator U2 compares the attenuated input loop signal to a reference voltage (about 0.078 V dc) applied across the differential input of U2. The reference voltage is developed by voltage divider action of 12 V dc applied through resistors R18 through R24 and is negative with respect to the plus-to-minus input of U2. Attenuated input loop signals greater than the reference voltage cause the output of U2 to go positive (about +3.2 V dc). This provides base current to keyer transistor Q2 causing it to turn on. When the AN/GRC-171 is operating in the remote mode, turned-on keyer transistor Q2 applies aground through REMOTE/LOCAL switch AlOAlS3 to the ptt key line (figure FO-16) to key the transmitter. Attenuated input loop signals less than the reference voltage cause the output of U2 to be negative (about -0.6 V dc). This causes keyer transistor Q2 to turn off and remove the ground from the ptt key line to unkey the transmitter.

4-300. For voltage loop keying, input loop voltage is applied to the input of keyer comparator U2 through the resistive divider formed by resistors R7, R8, R12, and R13 and the equivalent resistance of the reference voltage resistor network (resistors R18, R19, R20, and R21 in parallel with resistors R22 and R23, approximately 4890 ohms). The attenuation ratio of the resistive divider determines the input level (threshold) at which keying occurs. For 6-voltkeying (no strap), resistors R12 andR13 are test selected so that the resistive divider attenuates the input loop voltage by about -35 dB to set the keying threshold between 4 and 5 V dc (4.4 V dc nominal). For 26-volt keying, strapping E5 to E6 adds R11 to the resistive divider. This changes the attenuation of the resistive divider to about -47 dB to set the keying threshold at about 18 V dc. For 48-volt keying, strapping E3 to E4 (strap E5 to E6 removed) adds R10 to the resistive divider. This changes the attenuation of the resistive divider to about -52 dB to set the keying threshold at about 30 V dc. For 100-volt keying, strapping E1 to E2 (strap E3 to E4 removed) adds R9 to the resistive divider. This changes the attenuation of the resistive divider to about -56 dB to set the keying threshold at about 49 V dc.

4-301. For current loop keying, input loop current is applied through resistors R14 and R15. The voltage developed across R14 and R15 is applied to keyer comparator U2 through the resistive divider formed by resistors R16 and R17 and the approximate 4890-ohm equivalent resistance of the reference voltage resistor network. The resistive divider attenuates the voltage by about -26 dB to set the keying threshold at about 1.57 volts. This represents a current flow of about 14 milliamperes through resistors R14 and R15.

4-302. For audio loop keying, the audio tone is applied to the input of U2 through resistive divider R20-R21-R22-R23 which attenuates the input signal by about -'5.9 dB. Positive audio peaks which exceed the reference voltage (about 109 mV rms at the audio loop input) are amplified by U2 to produce a square- wave output. Diode CR3 rectifies and capacitor C3 filters the square wave to produce a dc voltage that turns keyer transistor Q2 on. For VOX operation, strapping of E7 to E8 adds capacitor C4 in parallel with capacitor C3. Capacitor C4 and resistors R25 and R26 determine the keyer attack and release times. When the output of keyer comparator U2 goes positive, the charge time of C4 through diode CR3 and the output impedance of U2 set the attack time at less than 10 milliseconds. When the output of U2 goes negative, CR3 is back biased. This causes C4 to discharge through R25 and R26 and the base resistance of Q2 to set the release time at about 1.25 seconds.

4-303. Zener diodes VR2, VR3, VR4, and VR5 limit the input voltage to keyer comparator U2 to about ±4 volts. This provides circuit protection against voltage spikes that may be conducted into the radio set on the voltage loop, current loop, or audio loop input lines.

4-304. CHASSIS A10.

4-305. Refer to the schematic diagram of figure FO-33. Chassis A10 contains connectors and wiring that interconnect the nine modules of the receiver-transmitter and provide connections through the emi filter (A10A3) to the rear panel power connector (J7), control connector (J6), and input/output connector (J22). Also contained on chassis A10 are power supply components and filter networks that form part of the power distribution circuit of the receiver-transmitter. The front panel (A01A1) of chassis A10 contains controls and indicators that are used to setup and locally operate and maintain the radio set. With the exception of the emi filter and the front panel meter and test points, all circuits of chassis A10 have been previously discussed and will not be repeated here.

4-306. EMI FILTER. The emi filter (A10A3 of figure FO-33) provides filtering for all wires that enter and leave the receiver-transmitter. This prevents internal interference from being conducted into the

receiver-transmitter and external noise from being conducted out of the receiver-transmitter by wiring to the radio set. In addition, all audio and data lines (J22-A through F and J22-L through S) that enter and leave have transient suppression circuits (A10A3CR3 through A10A3CR16, A10A3VR1, and A10A3VR2) that provide protection to the receiver-transmitter from destructive transient voltages or spikes.

4-307. TEST POINTS. Refer to figure FO-33 and to figures FO-14, FO-15, and FO-16. Test points A10A1TP1 through A10A1TP14 provide front panel access to signals within the receiver-transmitter and can be used to monitor system performance or as an aid to fault isolation. Refer to table 5-2 of chapter 5 for the signals monitored by each test point.

4-308. METER. Refer to figure FO-33. The meter provides indication of power supply voltages and signal levels within the receiver-transmitter and can be used to monitor system performance or as an aid to fault isolation. The meter consists of a 12-position selector switch (A10A1S2) and a meter circuit composed of dc milliameter A10A1M1, resistor A10A1R8, and diodes A10A1CR1 and A10A1CR2. Diodes A10A1CR1 and A10A1CR2 provide protection to the 0- to 1-milliampere dc milliameter from application of excessive voltage by shunting excess current around the dc mllliameter when the voltage drop across A10A1R8 in series with A10A1M1 exceeds about 200 millivolts. To measure voltage, resistors located in the voltage regulator and power amplifier modules are selected by A10A1S2. These resistors limit current through the meter in proportion to the voltage being measured to provide the proper indication on the meter scale. Meter accuracy is about 5 percent for voltage measurements and about 10 percent for power and percent modulation measurements.

4-309. Refer to table 5-2 of chapter 5 for the voltage and signals measured by each position of the selector switch.

SECTION III

FUNCTIONAL OPERATION OF MECHANICAL ASSEMBLIES

4-310. GENERAL.

4-311. This section contains a functional description of the mechanical tuning assembly of rf filter module A7. Refer to section II of this chapter for detailed description of the electronic circuits controlling and utilizing this mechanical assembly.

4-312. RF FILTER TUNING DRIVE ASSEMBLY.

4-313. Motor B1 is a dc motor that adjusts the rotor assembly of the rf filter and the position feedback potentiometer R20 through speed-reduction gears (figure 4-10). Gear MP1 on the motor drives the outer gear of MP2. The inner gear of MP2 rotates the outer gear of MP3. Gear MP3 rotates a shaft that positions the position feedback control R20. The inner gear of MP3 rotates gear MP4. Gear MP4 rotates the shaft connected to the rotor assembly of the rf filter.

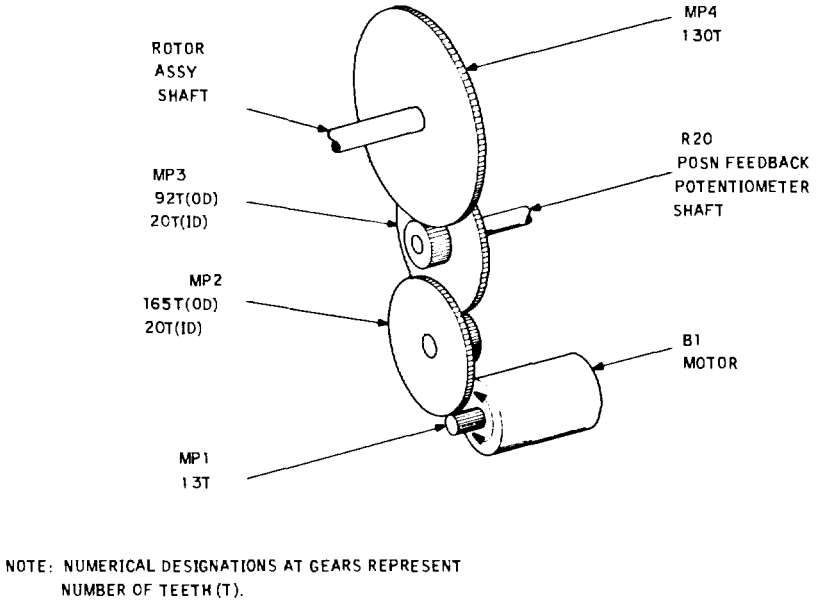

Figure 4-10. RF Filter Tuning Drive Assembly, Mechanical Diagram

CHAPTER 5

MAINTENANCE

INTRODUCTION

This chapter provides maintenance instructions for uhf AM Radio Set AN/GRC-171. Section I provides information on organizational/intermediate maintenance. Section II provides special maintenance procedures. This chapter presupposes that maintenance personnel are thoroughly familiar with the physical makeup and theory of operation of Radio Set AN/GRC-171.

SECTION I

ORGANIZATIONAL/INTERMEDIATE MAINTENANCE

5-1. GENERAL.

5-2. This section contains all maintenance instructions necessary for the organizational or intermediate maintenance technician.

5-3. MAINTENANCE TEST EQUIPMENT.

5-4. Table 5-1 lists the recommended test equipment required for checkout and maintenance of Radio Set AN/GRC-171. Equivalent test equipment may be used. Audio test fixture (figure FO-34) may be used to facilitate connecting test equipment to the RT-980/GRC-171.

5-5. TEST POINTS.

5-6. Table 5-2 lists all test points and provides a functional description for each test point. Refer to figure 5-1 for test point location.

Table 5-1. Test Equipment Required (Sheet 1 of 3)

TEST EQUIPMENT	TEST CHARACTERISTICS
RF Generator/Frequency Counter AN/USM -323	Rf generator Frequency Range: 225 to 400 MHz, ± 0.0015 MHz. Output level: 3.0 μV to 1.0 V. Modulation level: 30 to 90%. Modulation frequency: 400 to 10,000 Hz. Frequency counter: 225 MHz ±1125 Hz to 399.975 MHz ± 2000 Hz.
Boonton RF Voltmeter Model 91DA	0 to 30 ± 0.6 mV rms, 0 to 30 ± 0.06 V rms. Frequency range: 10 to 400 MHz.

Table 5-1. Test Equipment Required (Sheet 2 of 3)

TEST EQUIPMENT	TEST CHARACTERISTICS
HP 200CD Audio Oscillator	Frequency: 16 Hz to 25 kHz.
	Output level: 0 to 4.75 V rms into 600-ohm load.
	Distortion: Less than 0.50%.
HP 333A Distortion Analyzer	Distortion frequency range: 5 Hz to 600 kHz.
	Distortion level: 0 to 100%.
	Voltmeter (audio level): 0 to 9.0 V rms.
Bird Model 43 Wattmeter with Bird 50D Plug-in Element	Frequency range: 225 to 400 MHz.
	Power: 50 watts.
	Input/output impedance: 50 ohms, resistive.
General Radio 874-GAL Variable Attenuator	Power: 0 to 30 W.
	Attenuation: 0 to 60 dB.
	Frequency: 225 to 400 MHz.
	Input/output impedance: 50 ohms.
Bird 8130 RF Load	Power: 50 W.
	Frequency range: 225 to 400 MHz.
	Impedance: 50 ohms.
Simpson 260 VOM	0 to 30 V dc, ± 10%.
Measurements Corporation Type 80ZH3 Attenuator	Attenuation: 6 dB.
	Input/output impedance: 50 ohms.
Data Pulse Model 101 Pulse Generator	Pulse width: 2 to 12 ps.
	Pulse repetition rate: 300 to 1500 prf.
	Rise and fall time: Less than 1/10 μs.
	Amplitude: 5 V into 50 ohms.
Weinschel 1506N Power Divider	Two input ports and one output port.
	Frequency range: 225 to 400 MHz.
	Modulation: 2- to 12-ps pulse at 300 to 1500 prf.
	Input power: 500 mW average.
	Insertion loss: 6 dB.

Table 5-1. Test Equipment Required (Sheet 3 of 3)

TEST EQUIPMENT	TEST CHARACTERISTICS
Oscilloscope MIL-O-9960C	Dc: 0 to 150 V. Ac: 0 to 200 mV peak-to-peak. Display modulation envelope Rf frequency: 2 MHz. Modulation frequency: 1000 Hz. Modulation: 0 to 100%. Amplitude, vertical: 0.1 V/cm. Horizontal sweep: 0.5 ms/cm.
Fluke 8000A-01 Digital Multimeter	Audio: 0 to 1 V rms $\pm$ 3%. Dc: 0 to 10 V dc $\pm$ 1%, 0 to 26 V dc $\pm$ 2%, 0 to 100 V dc ± 10%, 0 to -4 V dc ± 1%, 0 to -12 V dc ± 4%.
HP 10514A Double Balanced Mixer	Frequency: 225 to 400 MHz. Modulation: 0 to 100%. Input: 40 mA maximum. Power: 5 mW nominal.
HP 6299A with Option 09 Power Supply	Voltage output: 0 to 100 V dc. Current output: 0 to 750 mA. Input voltage: 115 V ac. Input frequency: 48 to 440 Hz. Input current: 1.5 A. Power consumption: 135 W.
Handset H-169U	Transmitter: Low impedance, dynamic. Receiver: Impedance 600 ohms.

Table 5-2. Test Points (Sheet 1 of 4)

REFERENCE DESIGNATION	TEST POINT	FUNCTION	MODULE TO WHICH TEST POINT APPLIES
TEST meter A10A1M1	FWD PWR	Provides indication of transmitter forward power. Power will be 16 to 24 watts for antenna vswr of 3:1 or less.	Rf filter A7 and power amplifier A8

Table 5-2. Test Points (Sheet 2 of 4)

REFERENCE DESIGNATION	TEST POINT	FUNCTION	MODULE TO WHICH TEST POINT APPLIES
TEST meter A10A1M1	RE FLD PWR	Provides indication of antenna reflected power. Power will be 0 (1:1 vswr) to 5 (3:1 vswr) watts.	Antenna
TEST meter A1OA1M1	% MOD	Provides indication of transmitter rf carrier modulation. Percent of modulation will be 0 to 95%.	Rf filter A7, power amplifier A8, and audio A4
TEST meter A10A1M1	TEMP	Provides indication of power amplifier over temperature. Over temperature indicated when meter reads in OVER TEMP range.	Power amplifier A8
TEST meter A10A1M1	+26V	Provides indication of dc-dc converter output. Voltage will be +26 $\pm$ 1.5 V dc.	Dc-dc converter A5
TEST meter A10A1M1	+22V	Provides indication of +22-volt regulated supply output. Voltage will be +22 $\pm$ 1.5 V de.	Voltage regulator A6 and dc-dc converter A5
TEST meter A10A1M1	+12V	Provides indication of +12-volt regulated supply output. Voltage will be +12 $\pm$ 1.0 V de.	Voltage regulator A6 and dc-dc converter A5
TEST meter A10A1M1	+5V	Provides indication of +5.1-volt regulated supply output. Voltage will be +5.1 $\pm$ 0.5 V dc.	Voltage regulator A6 and dc-dc converter A5
TEST meter A10A1M1	-12V	Provides indication of -12-volt regulated supply output. Voltage will be -12 $\pm$ 1.0 V dc.	Voltage regulator A6 and dc-dc converter A5
A10A1TP1	SERVO +	Provides sample of servo motor (red lead) voltage. Voltage will be 0 to +6.5 V dc normal and 10 V de relative to SERVO - while tuning to a higher frequency.	D/a servo amplifier A1
A10A1TP2	SERVO -	Provides sample of servo motor (black lead) voltage. 0 to +6.5 V dc normal and 10 V dc relative to SERVO + while tuning to a lower frequency.	D/a servo amplifier A1
A10A1TP3	TUNE VOLT	Provides sample of servo position feedback voltage. Voltage will be -0.54 to -0.60 V dc (RT-980/ GRC-171 frequency of 300.000 MHz).	D/a servo amplifier A1 and rf filter A7

Table 5-2. Test Points (Sheet 3 of 4)

REFERENCE DESIGNATION	TEST POINT	FUNCTION	MODULE TO WHICH TEST POINT APPLIES
A10A1TP4	PLL OUT	Provides sample of frequency synthesizer phase-locked loop output level. Voltage will be + 0.5 to + 1.5 V dc.	Frequency synthesizer A2
A10A1TP5	PLL FAULT	Provides sample of frequency synthesizer lock monitor output. Voltage will be + 2.0 to + 5.0 V dc (locked) and 0 to + 0.5 V dc (unlocked).	Frequency synthesizer A2
A10A1TP6	PA FWD PWR	Provides sample of power amplifier power output. Voltage will be + 0.5 to + 1.2 V dc (16 to 24 watts).	Power amplifier A8
A10A1TP7	PA RE FLD PWR	Provides sample of reflected power at the power amplifier. Voltage will be - 0.3 to + 0.3 V dc (1:1 vswr) and + 0.7 V dc (3:1 vswr).	Rf filter A7 and power amplifier A8
A10A1TP8	ALC	Provides sample of power amplifier automatic load control voltage. Voltage will be + 0.5 to + 2.5 V dc (keyed) and + 12 V dc (unkeyed).	Power amplifier A8
A10A1TP9	KEY	Provides sample of key 2 output. Voltage will be + 0.05 to + 0.5 V dc (keyed) and + 3.8 V dc or greater (unkeyed).	Audio A4
A10A1TP10	RCV AUDIO	Provides sample of receiver audio output. Voltage will be 0.16 to 0.3 V rms.	Receiver rf A3
A10A1TP11	XMT AUDIO	Provides sample of audio module output (to modulator). Voltage will be 0 to 1.1 V rms.	Audio A4
A10A1TP12	IF AGC	Provides sample of AGC SQUELCH voltage. Voltage will be + 0.3 to - 0.7 Vdc (receive) and greater than + 0.6 V dc (transmit).	Receiver rf A3
A10A1TP13	RECT DC	Provides access to transformer rectifier output. Voltage will be + 21 to + 60 V dc.	Chassis A10
A10A1TP14	GND	Return for all front panel test points.	
A10W2J1/ A10W3J2	ANT-XCVR	Provides access to transmitter output or point of injection for receiver test signal.	Receiver rf A3, frequency synthesizer A2, and power amplifier A8

Table 5-2. Test Points (Sheet 4 of 4)

REFERENCE DESIGNATION	TEST POINT	FUNCTION	MODULE TO WHICH TEST POINT APPLIES
A10A1DS1	POWER (lamp)	Lamp is lit when power switch is closed and dc-dc converter is operating.	Chassis A10
A10A1DS2	READY (lamp)	Lamp is lit when frequency synthesizer (pll) is locked and servo loop is balanced.	D/a servo amplifier A1, frequency synthesizer A2, and rf filter A7
A10A1J4	MIC DYNAMIC	Handset audio input/output. Provides vocal/aural input or output as required.	Audio A4
A10A2J8 (rear panel)	IF	Provides access to receiver output (10.7 MHz) or point of injection of test signal.	Receiver rf A3
A10A1J3	HEADSET	Provides vocal/aural output as required.	Audio A4
A10A1J5	MIC CARBON	Provides vocal input as required.	Audio A4

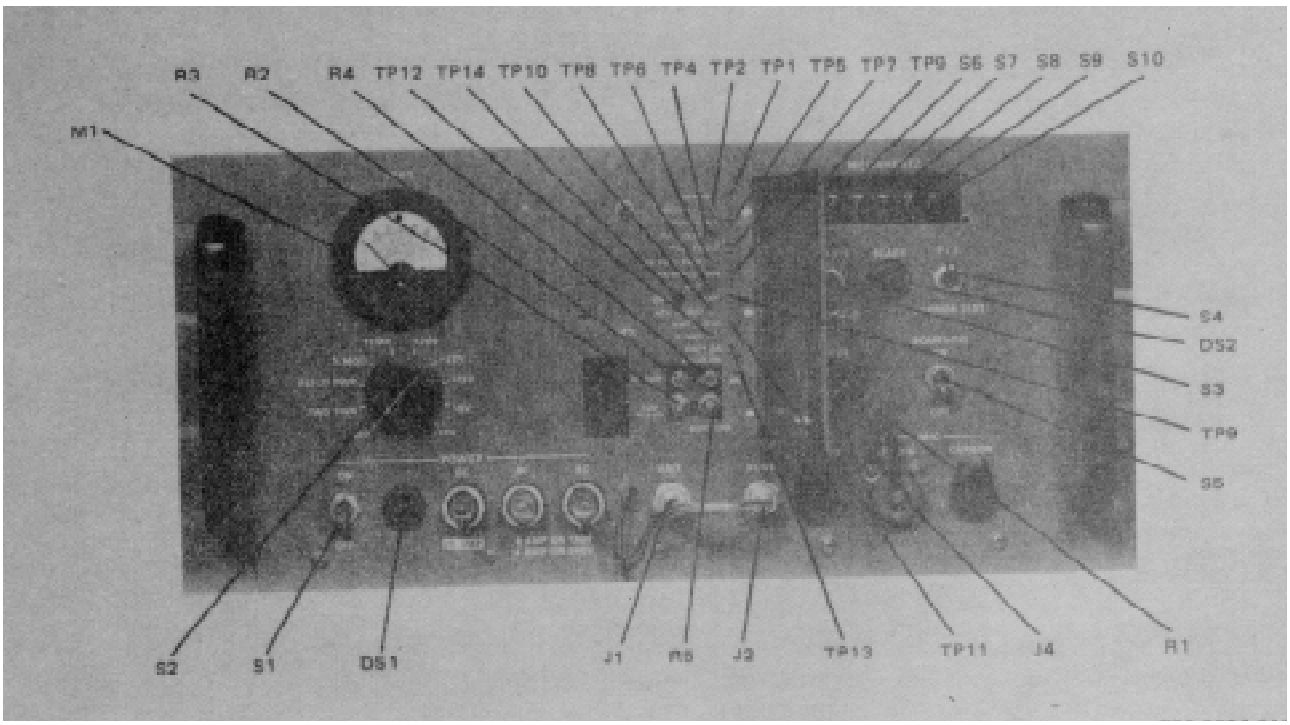

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Figure 5-1. Radio Receiver-Transmitter RT-980/GRC-171, Test Point Location

5-7. PERFORMANCE TESTS.

5-8. PERFORMANCE STANDARDS. Tables 5-3 and Radio Receiver-Transmitter RT-980/GRC-171 and 5-4 list the step-by-step procedures to be followed Radio Set Control C-7999/GRC-171 respectively, when performing performance standards tests on Radio Receiver-Transmitter RT-980.GRC-171 and Radio Set Control C-7999/GRC-171 respectively. If any step results in an incorrect response, trouble-shoot the radio set using Radio Set AN/GRC-171 troubleshooting procedures, figure 5-9, and block diagrams and schematic diagrams in chapters 4 and 6.

Table 5-3. Radio Receiver-Transmitter RT-980/GRC-171 Performance Tests (Sheet 1 of 17)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQIPMENT	PERFORMANCE STANDARD
POWER SUPPLY				
1	Connect rf load to RT-980/ GRC-171 antenna connec-tor (J9 rear panel).			
2		POWER lamp (A10A1DS1) and READY lamp (A10A1DS2)	Set RT-980/GRC-171 switches as follows: REMOTE/LOCAL to LOCAL, PTT/ CARRIER TEST to PTT, SQUELCH to OFF, TEST meter selector to OFF, POWER to ON.	POWER lamp and READY lamp are lit.
3		TEST meter (A10A1M1)	Rotate TEST meter selector through the following settings- and verify the readings: +26V +22V +12V +5V -12V TEMP	 26 ± 1.5 V dc. 22 ± 1.5 V dc. 12 ± 1.0 V dc. 5.1 ± 0.5 V dc. 12 ± 1.0 V dc. Meter does not read in OVER TEMP range.
4	Connect dvm to RT-980/ GRC-171 RECT DC test point.	RECT DC (A10A1TP13)		21 to 60 V dc.
RECEIVER MAIN AUDIO (NARROW BAND) OUTPUT				
5	Connect equipment as shown in figure 5-2.			

Table 5-3. Radio Receiver-Transmitter RT-980/'GRC-171 Performance Tests (Sheet 2 of 17)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARD
	RECEIVER MAIN AUDIO (NARROW BAND) OUTPUT (Cont)			
6	Connect distortion analyzer and 600-ohm load to RT-980/ GRC-171 AUDIO OUTPUT 1 and 2 (A10A2J22-N/'S).			
7	Set rf signal generator for rf output level 3 μV at 225.000 MHz, 30% modulation at 1 kHz.		Set REMOTE/LOCAL switch to LOCAL, PTT/CARRIER TEST switch to PTT, SQUELCH switch to OFF and frequency switches to 225.000 MHz.	
8	Set distortion analyzer FUNCTION control to VOLTMETER.	AUDIO OUTPUT (A10A2J22-N/S)	Adjust RCV AUDIO level control to obtain a main audio output level of 100 mW (7.75 V rms across 600-ohm load).	7.75 V rms.
9	Increase rf signal generator rf input level to 1.0 V (into 50 ohms) and determine increase in audio output from that measured in step 8.			Not more than 3 dB.
	RECEIVER SIGNAL-PLUS-NOISE TO NOISE RATIO			
10	Set rf signal generator for rf output level of 3.0 ,tV at 225.000 MHz, 30% modulation at 1 kHz. Observe distortion analyzer meter. Set the level to 0 dB (some convenient reference).			
11	Set distortion analyzer FUNCTION control to DISTORTION and determine noise level of 1 kHz signal in dB.			

Table 5-3. Radio Receiver-Transmitter RT-980/GRC-171 Performance Tests (Sheet 3 of 17)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQIPMENT	PERFORMANCE STANDARD
	RECEIVER SIGNAL-PLUS-NOISE TO NOISE RATIO (Cont)			
12	Determine signal-plus-noise to noise ratio as the dB decrease from step 10 to step 11.	AUDIO OUTPUT (A10A2J22-N/S)		Not less than 10 dB.
13	Repeat steps 7 through 12 for the following frequencies: 300.000 and 399.975 MHz.			Not less than 10 dB.
	RECEIVER WIDE-BAND AUDIO OUTPUT			
14	Connect equipment as shown in figure 5-2. Connect 10-kΩ load and distortion analyzer to RT-980/GRC-171 DATA OUTPUT (A10A2J22-L/M).			
15	Set rf signal generator for rf input level of 3.0 μV at 300.000 MHz, 30% modulation at 1 kHz. Measure wide-band audio output.	DATA OUTPUT (A10A2J22-L/M)	Set REMOTE/LOCAL switch to LOCAL, PTT/CARRIER switch to PTT, SQUELCH switch to OFF, and frequency switches to 300.000 MHz.	1.0 V rms or greater.
16	Increase rf signal generator rf input level to 6 μV.			1.0 V rms or greater.
	RECEIVER SQUELCH			
17 (Cont)	Set rf signal generator for rf output level of 50 RV at 300.000 MHz, 30% modulation at 1 kHz. Connect 600-ohm load and distortion analyzer to RT-980/GRC -171 AUDIO OUTPUT (A10A2J22-N/S). Connect vom to RT-980/ GRC-171 SQUELCH		Set SQUELCH switch to ON and frequency switches to 300.000 MHz.	

Table 5-3. Radio Receiver-Transmitter RT-980/GRC-171 Performance Tests (Sheet 4 of 17)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQIPMENT	PERFORMANCE STANDARD
		RECEIVER SQUELCH (Cont)		
17 (Cont)	RELAY NC and SQUELCH RELAY COM (A10A2J22-Z/a). Set vom for continuity check.			
18	Observe distortion analyzer and vom. N and S), SQUELCH RELAY NC (A10A2J22-Z) and SQUELCH RELAY COM (A10A2J22-a)	AUDIO OUTPUT (A10A2J22, pins		AUDIO OUTPUT: 7.25 to 9.0 V rms. SQUELCH RELAY COM to NC continuity: Not less than 100 kΩ.
19	Increase modulation to 90%. Observe distortion analyzer and vom.		Measure audio output increase in dB from that measured in step 18.	AUDIO OUTPUT increase: Not more than 3 dB. SQUELCH RELAY COM to NC continuity: Not less than 100 kΩ.
20	Reduce signal level to 25 μV. Observe distortion analyzer and vom.		Observe squelch gate closes and note audio output voltage.	AUDIO OUTPUT voltage: Not more than 0.1 V rms. SQUELCH RELAY COM to NC continuity: Not more than 1Ω.
21	Observe distortion analyzer and vom.		Set SQUELCH switch to OFF.	AUDIO OUTPUT voltage and SQUELCH RELAY COM to NC continuity returns to levels measured in step 19.
22			Repeat step 20 with REMOTE/ LOCAL switch set to REMOTE and C-7999/ GRC-171 frequency switches set to 300.000 MHz and SQUELCH switch set to ON.	Same as step 20.

Table 5-3. Radio Receiver-Transmitter RT-980/GRC-171 Performance Tests (Sheet 5 of 17)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQIPMENT	PERFORMANCE STANDARD
		RECEIVER SQUELCH (Cont)		
23	Set rf signal generator for rf input level of 3 μV at 300.00 MHz, 30% modulation at 1 kHz.		Set REMOTE/LOCAL switch to LOCAL and SQUELCH switch to ON. Adjust SQUELCH level control counter-clockwise until audio output signal is just obtained. Observe the audio output voltage.	7.25 to 9.0 V rms.
24			Remove rf signal input. Observe that squelch gate closes and note audio output voltage.	Not more than 0.03 V rms.
		RECEIVER HEADSET AUDIO		
25	With the equipment set up as in step 17, connect 600-ohm load and distortion analyzer to RT-980/GRC-171 HEADSET OUTPUT (A10A1J3).	HEADSET OUTPUT (A10A1J3)	Adjust VOL control to obtain output level of 100 mW (7.75 V rms).	7.75 V rms.
		RECEIVER NARROW-BAND AUDIO RESPONSE		
26	Connect equipment as shown in figure 5-2. Set rf signal generator for rf input level of 500 μV at 300.000 MHz, 30% modulation at 100 Hz to 10 kHz.	AUDIO OUTPUT (A10A2J22-N/S)	Set REMOTE/LOCAL switch to LOCAL, PTT/CARRIER TEST switch to PTT, SQUELCH switch to OFF, and frequency switches to 300.000 MHz.	
27	Set rf signal generator for 1000-Hz modulation signal.		Observe and note the audio output level.	This measurement will be a reference for measurements taken in step 28.

Table 5-3. Radio Receiver-Transmitter RT-980/GRC-171 Performance Tests (Sheet 6 of 17)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQIPMENT	PERFORMANCE STANDARD
	RECEIVER NARROW-BAND AUDIO RESPONSE (Cont)			
28	Set rf signal generator for the following modulation signals: a. 100 Hz b. 300 Hz. c. 3000 Hz. d. 10.000 Hz.		Observe and compare audio output level for each modulation frequency with reference level determined in step 27.	a. Not less than 10 dB below reference. b. Reference +1.0, -2.0 dB. c. Reference +1.0, -2.0 dB. d. Not less than 10 dB below reference.
	RECEIVER WIDE-BAND AUDIO RESPONSE			
29	Connect equipment as shown in figure 5-2 and connect 10-kΩ load and distortion analyzer to RT-980/GRC-171 DATA OUTPUT (A10A2J22-L/M). Set rf signal generator for rf input level of 500 μV at 300.000 MHz, 30% modulation at 16 Hz to 25 kHz.	DATA OUTPUT (A10A2J22-L/M)	Set REMOTE/LOCAL switch to LOCAL, PTT/CARRIER TEST to PTT, SQUELCH switch to OFF, and frequency switches to 300.000 MHz.	
	NOTE Before proceeding, inspect receiver rf module A3 to determine the bandpass of filter A3FL1. After determining filter A3FL1 bandpass, proceed with step 30 and applicable parts of step 31.			
30	Set rf signal generator for 1000-Hz modulation signal.		Observe and note the audio output level.	This measurement will be a reference for measurements taken in step 31.

Table 5-3. Radio Receiver-Transmitter RT-980/GRC-171 Performance Tests (Sheet 7 of 17)

<table>
<tr><th>STEP</th><th>OPERATION OF TEST EQUIPMENT</th><th>POINT OF TEST</th><th>CONTROL SETTINGS AND OPERATION OF EQIPMENT</th><th>PERFORMANCE STANDARD</th></tr>
<tr><td colspan="5">RECEIVER WIDE-BAND AUDIO RESPONSE (Cont)</td></tr>
<tr><td>31</td><td>Set rf signal generator for the following modulation frequencies:</td><td></td><td>Observe and compare audio output level for each modulation frequency with reference level determined in step 30.</td><td></td></tr>
<tr><td colspan="5">
<table>
<tr><th></th><th>20-kHz BW</th><th>36-kHz BW</th><th>60-kHz BW</th></tr>
<tr><td>a.</td><td>16 Hz</td><td>16 Hz</td><td>16 Hz</td></tr>
<tr><td>b.</td><td>300 Hz</td><td>300 Hz</td><td>300 Hz</td></tr>
<tr><td>c.</td><td>8 kHz</td><td>8 kHz</td><td>8 kHz</td></tr>
<tr><td>d.</td><td>NA</td><td>25 kHz</td><td>25 kHz</td></tr>
<tr><td>e.</td><td>20 kHz</td><td>36 kHz</td><td>60 kHz</td></tr>
</table>
<table>
<tr><th></th><th>20-kHz BW</th><th>36-kHz BW</th><th>60-kHz BW</th></tr>
<tr><td>a.</td><td>Ref +1,-3 dB</td><td>Ref +1,-3 dB</td><td>Ref +1,-3 dB</td></tr>
<tr><td>b.</td><td>Ref ±1 dB</td><td>Ref ±1 dB</td><td>Ref ±1 dB</td></tr>
<tr><td>c.</td><td>Ref ±1 dB</td><td>Ref ±1 dB</td><td>Ref ±1 dB</td></tr>
<tr><td>d.</td><td>NA</td><td>Ref ±1 dB</td><td>Ref ±1 dB</td></tr>
<tr><td>e.</td><td>Ref - 6 dB</td><td>Ref - 6 dB</td><td>Ref - 6 dB</td></tr>
</table>
</td></tr>
<tr><td colspan="5">RECEIVER AUDIO DISTORTION</td></tr>
<tr><td>32</td><td>Connect equipment as shown in figure 5-2 and connect 600-ohm load and distortion analyzer across RT-980/GRC-171 AUDIO OUTPUT (A10A2J22-N/S).</td><td>AUDIO OUTPUT (A10A2J22-N/S)</td><td>Set REMOTE/LOCAL switch to LOCAL, PTT/CARRIER TEST switch to PTT, SQUELCH switch to OFF, and frequency switches to 300.000 MHz.</td><td></td></tr>
<tr><td>33</td><td>Set rf signal generator for rf input level of 1.0 V (into 50-ohm load) at 300.000 MHz, 30% modulation at 1000 Hz.</td><td></td><td>Measure total distortion of receiver output.</td><td>Maximum 10%.</td></tr>
<tr><td>34</td><td>Increase rf signal generator modulation to 90%.</td><td></td><td>Measure total distortion of receiver output.</td><td>Maximum 15%.</td></tr>
</table>

Table 5-3. Radio Receiver-Transmitter RT-980/GRC-171 Performance Tests (Sheet 8 of 17)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARD
		IF OUTPUT		
35	Connect equipment as shown in figure 5-3. Set rf signal generator for rf output level of 6 μV at 300.000 MHz.	IF output (A10A2J8)	Set REMOTE/LOCAL switch to LOCAL, PTT/CARRIER TEST switch to PTT, SQUELCH switch to OFF, and frequency switches to 300.000 MHz. Measure the IF output voltage.	5 to 15 mV.
		RECEIVER IMAGE RESPONSE		
36	Connect equipment as shown in figure 5-4. Set rf signal generator for rf output level of 6 μV at 399.975 MHz.	IF AGC (A10A1TP12)	Set REMOTE/LOCAL switch to LOCAL, PTT/CARRIER TEST switch to PTT, SQUELCH switch to OFF, and frequency switches to 399.975 MHz. Measure and note IF AGC (A10A1TP12) voltage.	This measurement will be a reference for measurements taken in step 37.
37	Adjust rf signal generator for 339.975 MHz with 60,000-μV rf output.		Same as step 36. Observe and compare the IF AGC voltage with reference voltage determined in step 36.	More positive than reference voltage.
		NOISE BLANKER		
		NOTE The oscilloscope can be used as an aid in setting up the pulse generator pulse width and pulse recurrence frequency. Noise blanker operation can be observed with the oscilloscope connected to the RT-980/GRC-171 AUDIO OUTPUT (A10A2J22-N/S).		

Table 5-3. Radio Receiver-Transmitter RT-980/GRC-171 Performance Tests (Sheet 9 of 17)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARD
		NOISE BLANKER (Cont)		
38	Connect equipment as shown in figure 5-5. Set rf signal generator A for 300.000 MHz, 30% modulation at 400 Hz with rf output level of 6 μV (3 μV at RT-980/GRC-171 XCVR jack). Set rf signal generator B for minimum output.	AUDIO OUTPUT (A10A2J22-N/S)	Set REMOTE/'LOCAL switch to LOCAL, PTT/CARRIER TEST to PTT, SQUELCH switch to OFF, and frequency switches to 300.000 MHz.	
39	Using the distortion analyzer (distortion function and null 400-Hz modulation frequency), measure RT-980/GRC-171 signal/noise and record value.			10 dB or greater.
40	Adjust pulse generator for a 10-is, 2-V amplitude, 300-prf pulse. Adjust rf signal generator B for 100-μV pulse modulated output.			
41	Using the distortion analyzer, measure and record RT-980/GRC-171 signal/noise.			Less than 1.5-dB degradation from value measured in step 39.
42	With RT-980/GRC-171 noise blanker disabled, measure RT-980/GRC-171 signal/noise with the distortion analyzer.		Disable RT-980/GRC-171 noise blanker by grounding NOISE BLANKER DISABLE (A10A2J22-j).	At least 4 dB greater than value measured in step 41.
43	Repeat steps 40 through 42 using a modulation pulse of 10-ps, 2-V amplitude, and 1500 prf.			Step 41 will have less than 2-dB degradation from value measured in step 39. Step 42 will be at least 4 dB greater than value measured in step 41.

Table 5-3. Radio Receiver-Transmitter RT-980/GRC-171 Performance Tests (Sheet 10 of 17)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARD
TRANSMITTER POWER OUTPUT, REFLECTED POWER, AND FREQUENCY				
NOTE The following steps require the transmitter to be keyed. Transmitter duty cycle is 9 minutes on and 1 minute off.				
44	Connect equipment as shown in figure 5-6. Set variable attenuator to 60 dB.			
45	While transmitter is keyed, reduce variable attenuator until frequency counter stabilizes (between 20 and 10 dB). After observing forward power, set wattmeter for reflected power and observe reflected power.	XCVR (A10W3J2)	Set frequency switches to 300.000 MHz and PTT/ CARRIER TEST to CARRIER TEST. Observe wattmeter and frequency counter.	Forward power: 16 to 24 watts. Reflected power: Not more than forward power divided by 4. Frequency: 300.000 ± 0.0015 MHz.
46			Repeat step 45 for 225.000 MHz.	Forward and reflected power same as step 45. Frequency: 225.000 ± 0.001125 MHz.
47			Repeat step 45 for 399.975 MHz.	Forward and reflected power same as step 45. Frequency: 399.975 ± 0.001999 MHz.
48			Set REMOTE/LOCAL switch to LOCAL, PTT/CARRIER TEST switch to PTT, POWER switch to ON.	
49		XCVR (A10W3J2)	Set 100-MHz digit of frequency selector switches to position 3 And turn each of the remaining switches through its range. Key transmitter at each selected frequency and observe frequency counter.	Frequency set on frequency select switches ± 1.125 kHz. If error exceeds 1.125 kHz, compute actual allowable frequency range (selected frequency ± 0.0005%).

Table 5-3. Radio Receiver-Transmitter RT-980/GRC-171 Performance Tests (Sheet 11 of 17)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARD
	TRANSMITTER NARROW-BAND MODULATION			
50	Connect equipment as shown in figure 5-6. Set audio oscillator for 2.45 V rms (+10 dB mW) at 1000-Hz input to RT-980/ GRC-171 as observed on digital multimeter. Set rf signal generator to 298.000 MHz. While observing oscilloscope display, adjust rf signal generator output level to obtain RT-980/ GRC-171 modulation envelope.	XCVR (A10W3J2)	Set REMOTE/LOCAL switch to LOCAL, PTT/CARRIER TEST switch to CARRIER TEST, SQUELCH switch to OFF, and frequency switches to 300.000 MHz.	
51	Measure and determine the modulation percentage using the oscilloscope display and the following formula: $M = \frac{E_{MAX} - E_{MIN}}{E_{MAX} + E_{MIN}} \times 100\%$		Adjust % MOD adjustment if necessary to obtain required percent of modulation.	85 to 95%.
52	Set audio oscillator level for 0.135 V rms (-15 dB mW) at 1000-Hz input to RT-980/GRC-171 as observed on digital voltmeter. Measure and determine modulation percentage.			75 to 95%.
53	Set audio oscillator level for 7.75 V rms (+20 dB mW) at 1000-Hz input to RT-980/ GRC-171 as observed on digital voltmeter.			Observe that overmodulation does not occur (a minimum rf level of zero corresponds to overmodulation of the RT-980/GRC-171).

Table 5-3. Radio Receiver-Transmitter RT-980/GRC-171 Performance Tests (Sheet 12 of 17)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARD
		TRANSMITTER WIDE-BAND MODULATION		
54	Disconnect audio oscillator from RT-980/GRC-171 main audio input. Connect audio oscillator to RT-980/GRC-171 DATA INPUT (A10A2J22-A/B).			
55	Set audio oscillator level for 0.775 V rms (0 dB mW) at 1000-Hz input to RT-980/GRC-171 as observed on digital voltmeter. Determine modulation percentage.	DATA INPUT (A10A2J22-A/B)		85 to 95%.
		TRANSMITTER SIDETONE		
56	Connect equipment as shown in figure 5-7.			
57	Set audio oscillator for 2.45 V rms at 1000-Hz input to RT-980/GRC-171. sidetone audio.	AUDIO OUTPUT (A10A2J22-N/S)	Adjust SIDE TONE adjustment if necessary to obtain required	7.75 V rms (100 mW).
		MODULATION DISTORTION		
58	Connect equipment as shown in figure 5-7. Set audio oscillator for 1-kHz tone. 0.135-V output.		Set RT-980/GRC-171 REMOTE/LOCAL switch to LOCAL, SQUELCH switch to OFF. PTT/CARRIER TEST to PTT, and frequency selectors to 300.000 MHz.	
59	Using distortion analyzer, measure the modlation distortion.	AUDIO OUTPUT (A10A2J22-N/S)		Less than 10%.

Table 5-3. Radio Receiver-Transmitter RT-980/GRC-171 Performance Tests (Sheet 13 of 17)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARD
		TRANSMITTER KEYING		
		NOTE Squelch relay, A9K1, is a mercury-wetted contact type relay. For the squelch relay to function properly, the RT-980/GRC-171 must be in its normal operating position.		
60	Connect rf load to RT-980/GRC-171 antenna connector (J9 rear panel). Connect C-7999/ GRC-171 to RT-980/GRC-171.	TEST meter (A10A1M1)	Set RT-980/GRC-171 switches as follows: REMOTE/LOCAL to REMOTE, PTT/ CARRIER TEST to PTT, SQUELCH to OFF, TEST meter selector to FWD PWR, and POWER to ON.	
61			Set C-7999/GRC-171 switches as follows: PWR to ON, SQLCH to OFF.	
		NOTE Inspect audio module A4 and keyer module A9 to determine strapping options used. Perform applicable sections of steps 62, 63, and 66.		
62		TEST meter (A10A1M1)	a. Key transmitter by grounding the center tap of the AUDIO INPUT (A10A2J22-D/E) thru a 3300-ohm resistor. Observe the transmitter is keyed.	a. Power indication TEST meter.
(Cont)	b. Adjust power supply for 6-V dc output and connect the power supply voltage output to RT-980/GRC-171 connector A10A2J22-D/E.		b. Observe the transmitter is keyed.	b. Power indication on TEST meter.

Table 5-3. Radio Receiver-Transmitter RT-980/GRC-171 Performance Tests (Sheet 14 of 17)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARD
		TRANSMITTER KEYING (Cont)		
62 (Cont)	c. Adjust power supply for 26-V dc output and connect the power supply voltage output to RT-980/GRC-171 connector A10A2J22-D/E.		c. Observe the transmitter is keyed.	c. Power indication on TEST meter.
	d. Adjust power supply for 48-V dc output and connect the power supply voltage output to RT-980/GRC-171 connector A10A2J22-D/E.		d. Observe the transmitter is keyed.	d. Power indication on TEST meter.
63			a. Remove 3300-ohm resistor from AUDIO INPUT center tap (A10A2J22-D/E).	
	b. Disconnect power supply from RT-980/GRC-171.			
	c. Disconnect power supply from RT-980/GRC-171.			
	d. Disconnect power supply from RT-980/GRC-171			
64		TEST meter (A10A1M1)	Key transmitter by grounding the REMOTE PTT (A10A2J22-J). Observe the transmitter is keyed.	Power indication on TEST meter.
65		TEST meter (A10A1M1)	Set RT-980/GRC-171 REMOTE/LOCAL switch to LOCAL. Key transmitter by grounding DYNAMIC MIC PTT line (A10A1J4-E).	Power indication on TEST meter.

Table 5-3. Radio Receiver-Transmitter RT-980/GRC-171 Performance Tests (Sheet 15 of 17)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARD
	TRANSMITTER KEYING (Cont)			
66	a. Adjust power supply for 6-V dc output and and connect power supply to RT-980/ GRC-171 VOLTAGE LOOP input (A10A2J22-X/Y).	TEST meter (A10A1M1)	a. Observe the transmitter is keyed.	a. Power indication on TEST meter.
	b. Adjust power supply for 26-V dc output and connect power supply to RT-980/ GRC-171 VOLTAGE LOOP input (A10A2J22-X/Y).		b. Observe the transmitter is keyed.	b. Power indication on TEST meter.
	c. Adjust power supply for 48-V dc output and connect power supply to RT-980/ GRC-171 VOLTAGE LOOP input (A10A2J22-X/Y).		c. Observe the transmitter is keyed.	c. Power indication on TEST meter.
	d. Adjust power supply for 100-V dc output and connect power supply to RT-980/ GRC-171 VOLTAGE LOOP input (A10A2J22-X/Y).		d. Observe the transmitter is keyed.	d. Power indication on TEST meter.
67	Adjust power supply to current limit at 20 mA and connect power supply to RT-980/ GRC-171 CURRENT LOOP input (A10A2J22-V/W).	TEST meter (A10A1M1)	Observe the transmitter is keyed.	Power indication on TEST meter.
68	Disconnect power supply from RT-980/GRC-171.			
69	Connect audio oscillator to RT-980/GRC-171 AUDIO LOOP input (A10A2J22-T/U) and adjust audio oscillator for 1000-Hz tone at 0.245-V rms output.	TEST meter (A10A1M1)	Observe the transmitter is keyed.	Power indication on TEST meter.

Table 5-3. Radio Receiver-Transmitter RT-980/GRC-171 Performance Tests (Sheet 16 of 17)

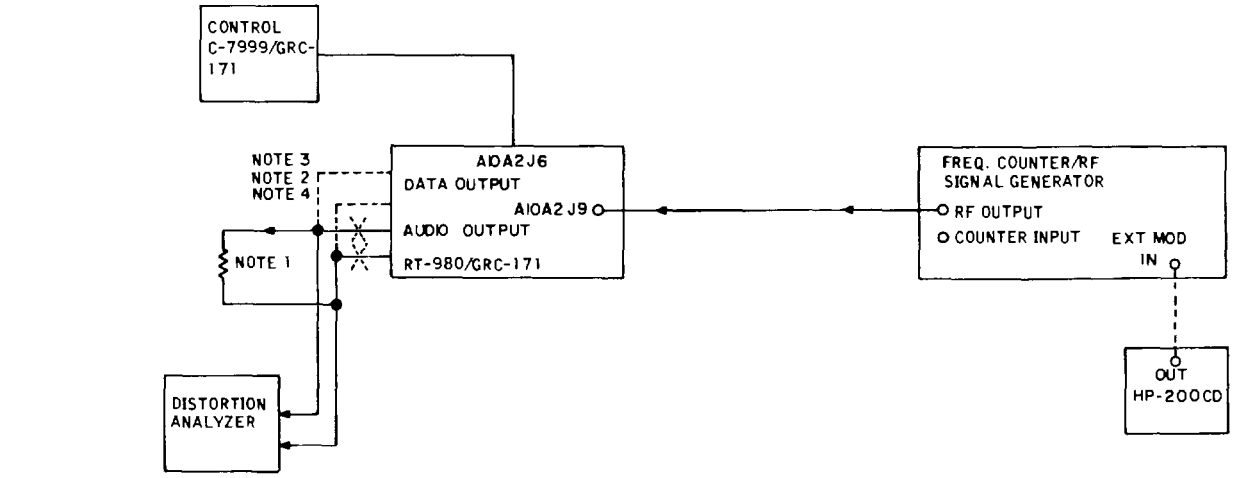
STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARD
		TRANSMITTER KEYING (Cont)		
70	Disconnect audio oscillator from RT-980/GRC-171.			
		RADIO RECEIVER-TRANSMITTER OPERATIONAL PERFORMANCE		
71	Connect RT-980/GRC-171, C-7999/GRC-171, and antenna as for normal operation. Connect Handset H-169U to RT-980/GRC-171 DYNAMIC MIC jack. meter selector to OFF, POWER to ON, and frequency selector to an authorized assigned frequency.		Set RT-980/GRC-171 switches as follows: REMOTE/LOCAL to LOCAL, SQUELCH to ON, PTT/CARRIER TEST to PTT, TEST	
72		TEST meter (A10A1M1)	Key transmitter and rotate the TEST meter selector through the following settings and verify readings:	
			FWD PWR	16 to 24 watts.
			RFLD PWR	Not more than 25%, of forward power.
			% MOD (talk into handset microphone on this setting)	Observe needle movement.
			TEMP	Meter does not read in OVER TEMP range.
			+26V	26 ± 1.5 V dc.
			+22V	22 ± 1.5 V dc.
			+12V	12 ± 1.0 V dc.
			+5V	5.1 ± 0.5 V dc.
			-12V	12 ± 1.0 V dc.
73	Connect digital multimeter to the following RT-980/GRC-171 front panel test points and verify readings:		Key transmitter.	
(Cont)	TUNE VOLT	TUNE VOLT (A10A1TP3)		-0.54 to -0.60 V dc (300.000 MHz).

Table 5-3. Radio Receiver-Transmitter RT-980/GRC-171 Performance Tests (Sheet 17 of 17)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARD
		RADIO RECEIVER-TRANSMITTER OPERATIONAL PERFORMANCE (Cont)		
73 (Cont)	PLL OUT	PLL OUT (A10A1TP4)		0.5 to 1.5 V dc.
	PLL FAULT (A10A1TP5)	PLL FAULT		2.0 to 5.0 V dc.
	PA FWD (A10A1TP6)	PA FWD		0.5 to 1.2 V dc.
	PA REFL (A10A1TP7)	PA RE FL		-0.3 to 0.3 V dc.
	ALC (A10A1TP8)	ALC		0.5 to 2.5 V dc.
	KEY (A10A1TP9)	KEY		0.05 to 0.5 V dc.
	XMT AUDIO (A10A1TP11)	XMIT AUDIO	Whistle or hum into microphone.	0.6 to 1.1 V rms.
	RECT DC (A10A1TP13)	RECT DC		21 to 60 V dc.
74	Connect vom between SERVO + and GND and SERVO - and GND test points on the RT-980/GRC-171.	SERVO + (A10A1TP1) GND (A10A1TP14) SERVO - (A10A1TP2)		SERVO+ and SERVO- to ground (in quiescent state) 0 to 6.5 V dc.
75	Connect digital multi-meter to the following RT-980/GRC-171 test points and verify readings:		Unkey transmitter.	
	RCV AUDIO	RCV AUDIO (A10A1TP10)		0.16 to 0.3 V rms.
	IF AGC	IF AGC (A10A1TP12)		-0.3 to -0.7 V dc.
76	Turn off and disconnect all test equipment from RT-980/GRC-171. required.		Place Radio Set AN/GRC-171 in operational status	

Table 5-4. Radio Set Control C-7999/GRC-171 Performance Test

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARD
1	Connect equipment as shown in figure 5-8. Set variable attenuator to 60 dB. and POWER ON/ OFF switch to ON.		Set RT-980/GRC-171 REMOTE/LOCAL switch to REMOTE	
2		C-7999/GRC-171 panel lights and READY lamp	On C-7999/GRC--171 set PWR switch to ON.	C-7999/GRC-171 is lit and READY lamp is on.
3	Reduce variable attenuator setting until frequency counter stabilizes (20 to 10 dB).	XCVR (A10W3J2)	Set 100-MHz digit of remote frequency select switches to position 3 and turn each of the remaining switches through its range. Key the transmitter from the remote station at each selected frequency and observe the frequency counter.	Frequency set on frequency select switches $\pm$ 1.125 kHz. If error exceeds 1.125 kHz, compute actual allowable error (selected frequency $\pm$ 0.0005%).
4		RT-980/GRC-171 front panel and C-7999/GRC-171 front panel	On C-7999/GRC-171 set PWR switch to OFF	RT-980/GRC-171 POWER lamp and C-7999/GRC-171 READY lamp are OFF.
5			On C-7999/GRC-171 set PWR switch to ON.	RT-980/GRC-171 POWER lamp and C-7999/GRC-171 READY lamp are ON.
6			Set C-7999/GRC-171 PWR switch to OFF and RT-980/ GRC-171 REMOTE/ LOCAL switch to LOCAL.	
7	Turn off and disconnect all test equipment from Radio Set AN/GRC-171.		Place Radio Set AN/GRC-171 in operational status required.	

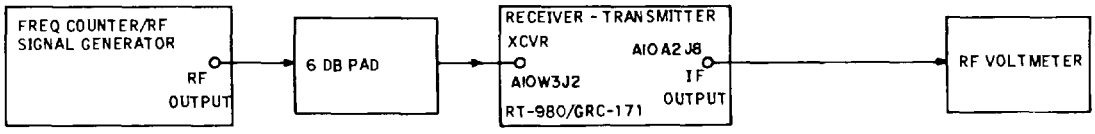


NOTES:

1. RESISTANCE IS 600 OHMS FOR MAIN AUDIO OUTPUT LOAD AND 10,000 OHMS FOR WIDEBAND AUDIO OUTPUT LOAD.
2. DASHED LINE DENOTE CONNECTIONS FOR WIDEBAND AUDIO OUTPUT MEASUREMENTS.
3. AUDIO OUTPUT A1OA2J22 PINS N AND S (JUMPER PINS P AND R) DATA AUDIO OUTPUT A1OA2J22 PIN L AND GND PIN M
4. IF AUDIO TEST FIXTURE (REFER TO FIGURE FO-34) IS AVAILABLE, IT MAY BE USED TO CONNECT TEST EQUIPMENT TO A1OA2J22.

TP3-9747-013

Figure 5-2. Test Setup for Receiver Sensitivity, AGC Squelch and Compressor Performance, Narrow- and Wide-Band Receiver Response, and Receiver Audio Distortion



TP3-9749-013

Figure 5-3. Test Setup for IF Measurement

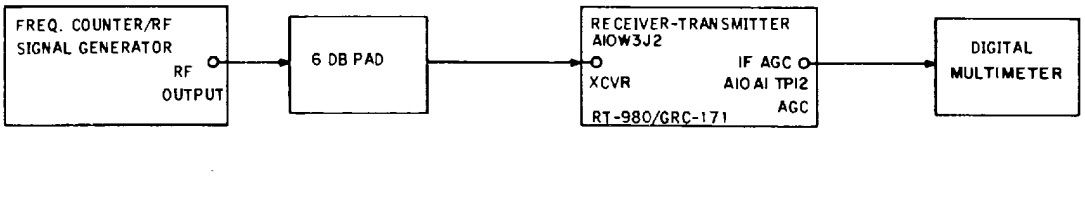


Figure 5-4. Test Setup for Image Response

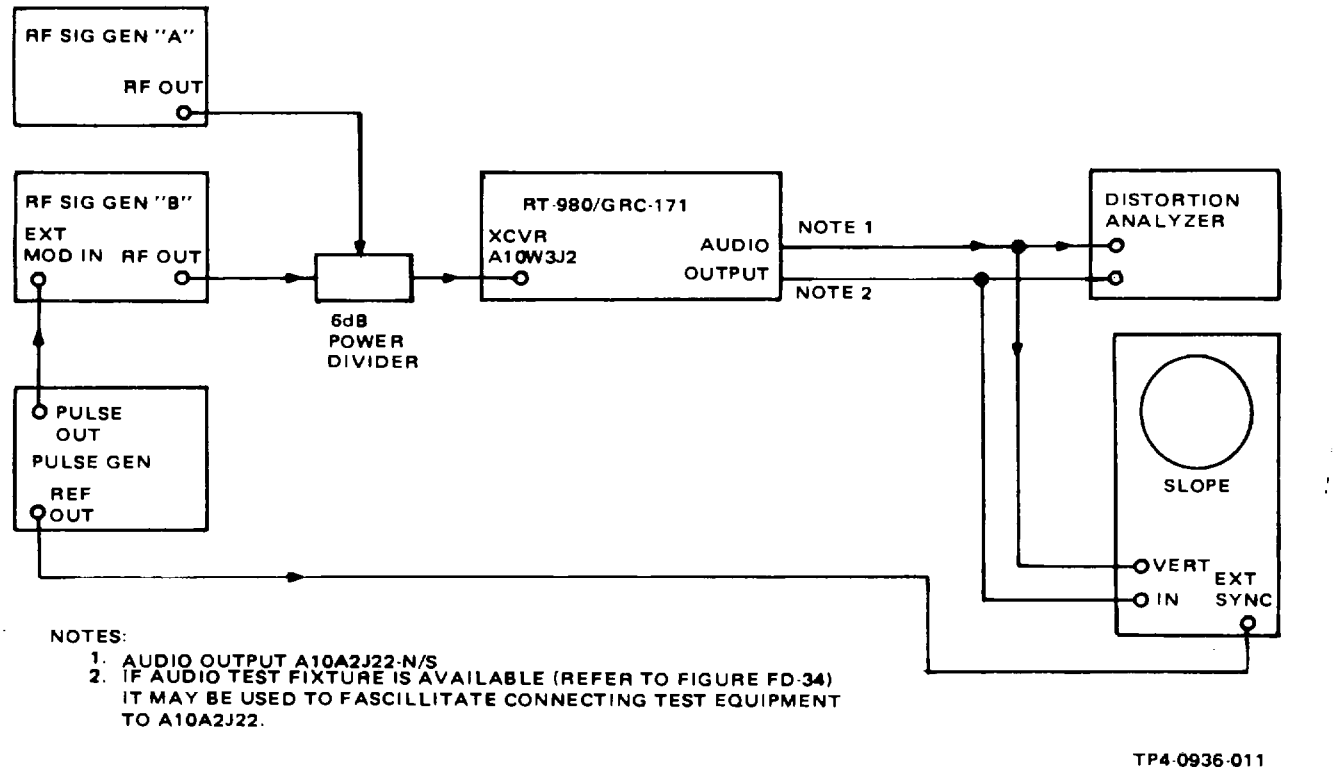
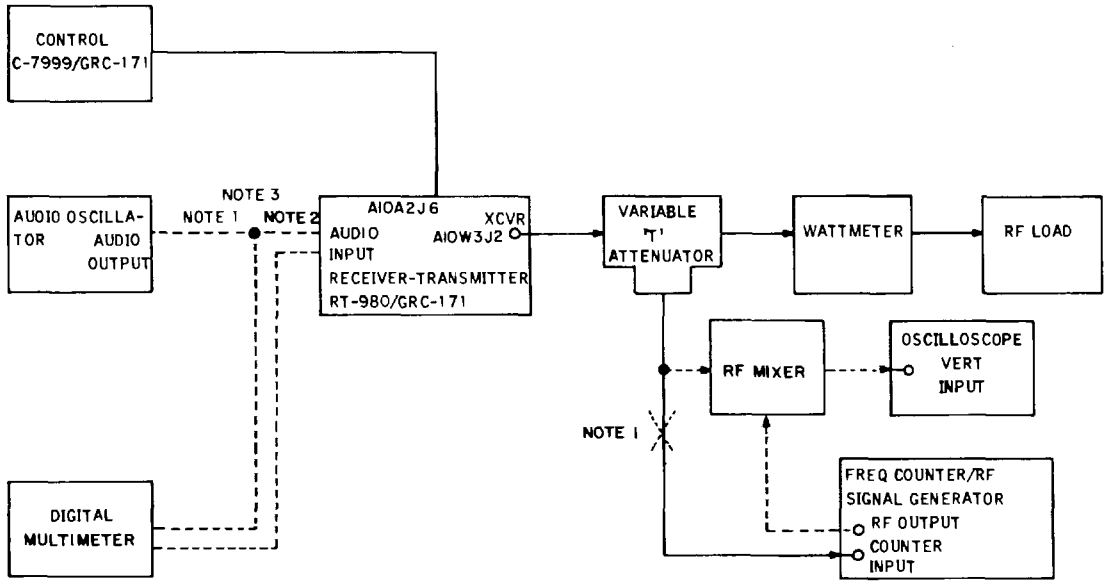


Figure 5-5. Test Setup for Noise Blanker Test

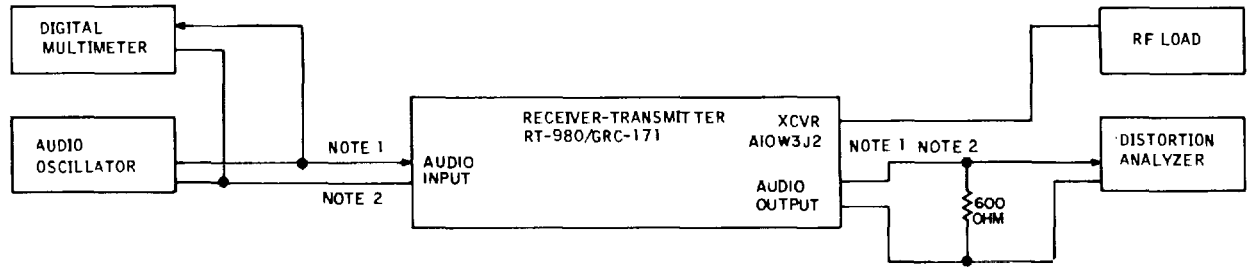


NOTE:

1. DASHED LINES INDICATE CONNECTIONS FOR MODULATION CHECKS.
2. AUDIO INPUT A1OA2J22 PINS C AND F (JUMPER PINS D AND E) DATA INPUT A1OA2J22 PIN A
3. IF AUDIO TEST FIXTURE (REFER TO FO-341), IS AVAILABLE, IT MAY BE USED TO CONNECT TEST EQUIPMENT TO A1OA2J22.

TP3-9748-01

Figure 5-6. Test Setup for RF Power Output, Frequency Tolerance, and Modulation



NOTE:

1. 600 OHM MAIN AUDIO INPUT A1OA2J22 PINS C AND F (JUMPER J22 PINS D AND E)
   600 OHM MAIN AUDIO OUTPUT A1OA2J22 PINS N AND S (JUMPER J22 PINS P AND R)
2. IF AUDIO TEST FIXTURE (REFER TO FO-341) IS AVAILABLE, IT MAY BE USED TO CONNECT TEST EQUIPMENT TO A1OA2J22.

TP3-9819-013

Figure 5-7. Test Setup for Transmitter Sidetone and Modulation Distortion

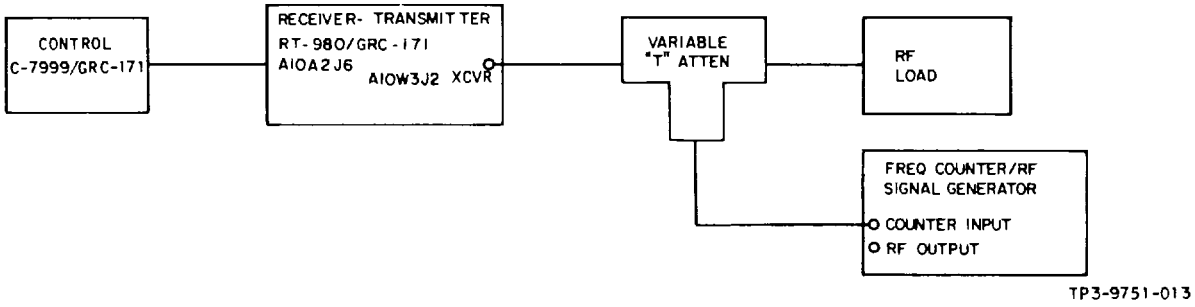


Figure 5-8. Test Setup for Radio Set Control C-7999/GRC-171

5-9. VOLTAGE REQUIREMENTS AND SOURCES.

5-10. Radio Set AN/GRC-171 and test equipment require 120-V ac, 60-Hz, single-phase power for operation.

5-11. ALIGNMENT.

5-12. No alignment is required at the organizational/ intermediate maintenance level. Alignment is performed at the module level and is covered in section H.

5-13. ADJUSTMENT.

5-14. RECEIVE AUDIO. To adjust the receive audio level, connect equipment as shown in figure 5-2 and proceed as follows:

a. Connect distortion analyzer and 600-ohm load across the RT-980/GRC-171 main audio output.

b. Set the rf signal generator for rf output level of 3 μV at 225.000 MHz, 30 percent modulation at 1 kHz.

c. Set the RT-980/GRC-171 REMOTE/LOCAL switch to LOCAL, PTT/CARRIER TEST switch to PTT, SQUELCH switch to OFF, and frequency switches to 225.000 MHz.

d. Set distortion analyzer FUNCTION control to VOLTMETER and observe RT-980/GRC-171 main audio output voltage.

e. Adjust RCV AUDIO level control (behind front panel access door) to obtain 7.75 V rms (100 mW) across the 600-ohm load.

5-15. SQUELCH. To adjust the squelch level, connect equipment as shown in figure 5-2 and proceed as follows.

a. Connect distortion analyzer and 600-ohm load across the RT-980/GRC-171 main audio output.

b. Set the rf signal generator for rf output level of 2 to 2.5 μV at 300.000 MHz, 30 percent modulation at 1 kHz.

c. Set the RT-980/GRC-171 REMOTE/LOCAL switch to LOCAL, PTT/CARRIER TEST switch to PTT, SQUELCH switch to ON, and frequency switches to 300.000 MHz.

d. Set distortion analyzer FUNCTION control to VOLTMETER and observe RT-980/GRC-171 main audio output voltage.

e. Adjust SQUELCH level control (behind front panel access door) counterclockwise from maximum until an audio output signal is obtained (main audio output voltage will be 7.25 to 9.0 V rms).

5-16. MODULATION PERCENTAGE. To adjust the transmitter modulation percentage, connect equipment as shown in figure 5-5 for modulation check and proceed as follows:

a. Set the RT-980/GRC-171 REMOTE/LOCAL switch to LOCAL, PTT/CARRIER TEST switch to CARRIER TEST, SQUELCH switch to OFF, and frequency switches to 300.000 MHz.

b. Set audio oscillator output for 2.45 V rms (+10 dB mW) at 1000-Hz input to RT-980/GRC-171 as observed on the digital multimeter.

c. Set rf signal generator to 298.000 MHz and while observing oscilloscope display, adjust rf signal generator output to obtain the RT-980/GRC-171 modu-lation envelope.

d. Measure and determine modulation percentage using the oscilloscope display and the following formula:

$$M = \frac{E_{MAX} - E_{MIN}}{E_{MAX} + E_{MIN}} \times 100\%$$

e. Adjust % MOD control (behind front panel access door) to obtain 85 to 95 percent modulation.

NOTE

Ensure that over modulation does not occur. A minimum rf level of zero corresponds to over modulation of the RT-980/GRC-171.

5-17. SIDETONE. To adjust transmitter sidetone, connect equipment as shown in figure 5-6 for transmitter power output and proceed as follows:

a. Connect audio oscillator and 600-ohm load across the RT-980/GRC-171 main audio input.

b. Connect distortion analyzer and 600-ohm load across the RT-980/GRC-171 main audio output and set distortion analyzer FUNCTION control to VOLTMETER.

c. Set audio oscillator output for 2.45 V rms at 1000-Hz input to RT-980/GRC-171 as observed on digital multimeter.

d. Set RT-980/GRC-171 REMOTE/LOCAL switch to LOCAL, PTT/CARRIER TEST switch to CARRIER TEST, SQUELCH switch to OFF, and frequency switches to 300.000 MHz.

e. Adjust SIDETONE level control (behind front panel access door) to obtain 7.75 V rms (100 mW) audio output as observed on distortion analyzer VOLTMETER.

5-18. TROUBLESHOOTING.

5-19. Troubleshooting procedures are presented in flow-chart form. Figure 5-9 is the troubleshooting procedures for Radio Set AN/GRC-171. In troubleshooting Radio Set AN/GRC-171, use the block diagrams and schematic diagrams of chapters 4 and 6 with the troubleshooting procedures of figure 5-9 for trouble analysis and location.

5-20. REMOVAL/REPLACEMENT.

CAUTION

Turn power off before removal or replacement of any module.

5-21. D/A SERVO AMPLIFIER MODULE A1.

5-22. REMOVAL OF MODULE. To remove d/a servo amplifier module from chassis, refer to figure 5-10 and proceed as follows:

a. Remove top cover.

b. Loosen six captive screws around periphery of module retainer bracket and remove bracket.

c. Disconnect transmit rf cable A10A2P1 from A2A6J1.

d. Remove module by carefully sliding module to the rear, disengaging A1P1 from A10A2J10, and lifting module from chassis.

5-23. REPLACEMENT OF MODULE. Replace module in the reverse order of its removal.

CAUTION

Ensure proper module-to-chassis plug and pin alignment is achieved before sliding module into position. Do not exert abnormal force to seat module.

5-24. FREQUENCY SYNTHESIZER MODULE A2.

5-25. REMOVAL OF MODULE. To remove frequency synthesizer module from chassis, refer to figure 5-10 and proceed as follows:

a. Remove top cover.

b. Loosen six captive screws around periphery of module retainer bracket and remove bracket.

c. Disconnect transmit rf cable A10A2P1 from A2A6J1 and the receive injection cable A2A6P2 from A3J1.

d. Remove module by carefully sliding module to the rear, disengaging A2P1 from AlOA2Jll, and lifting module from chassis.

5-26. REPLACEMENT OF MODULE. Replace module in the reverse order of its removal.

CAUTION

Ensure proper module-to-chassis plug and pin alignment is achieved before sliding module into position. Do not exert abnormal force to seat module.

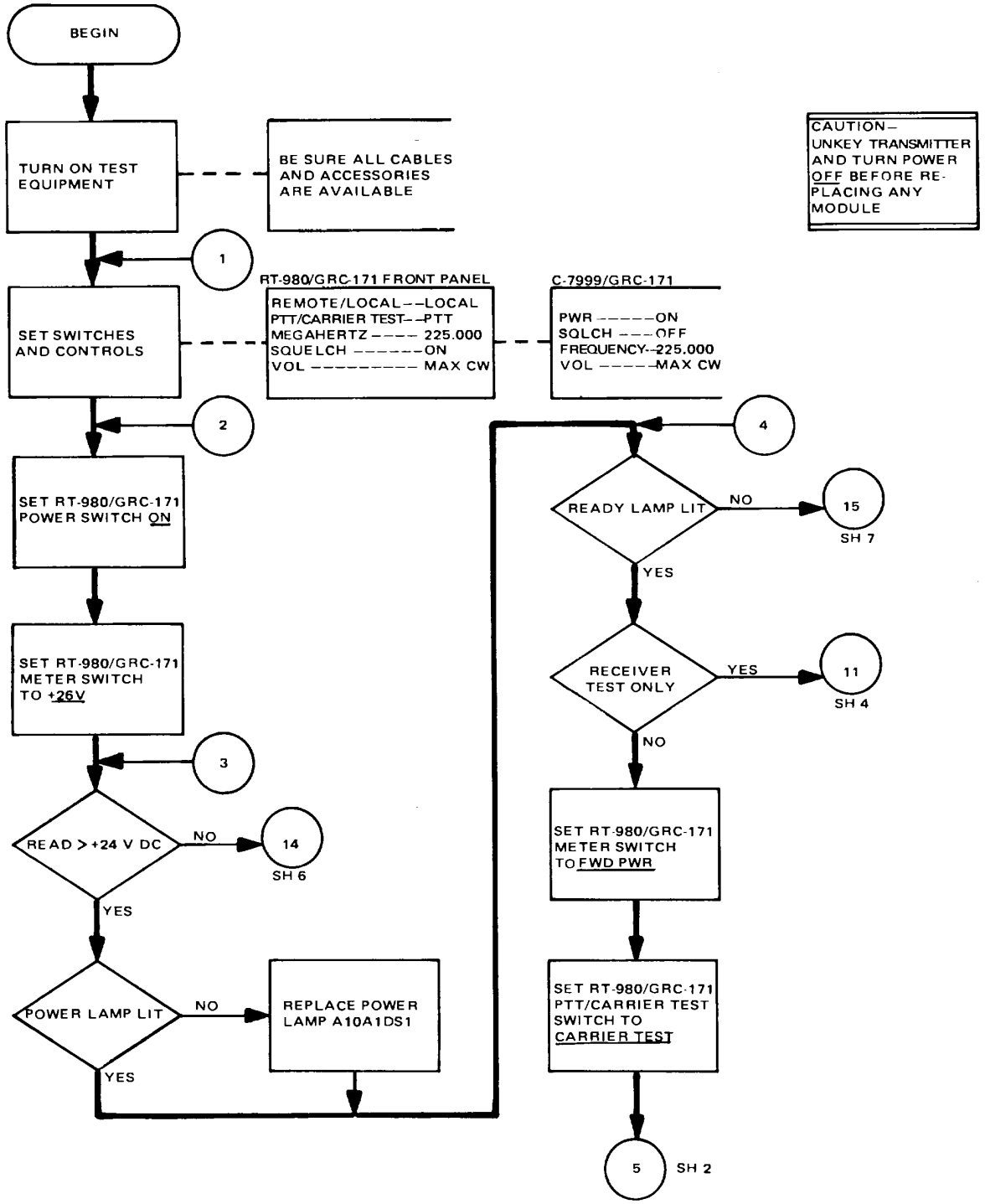


Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 1 of 17)

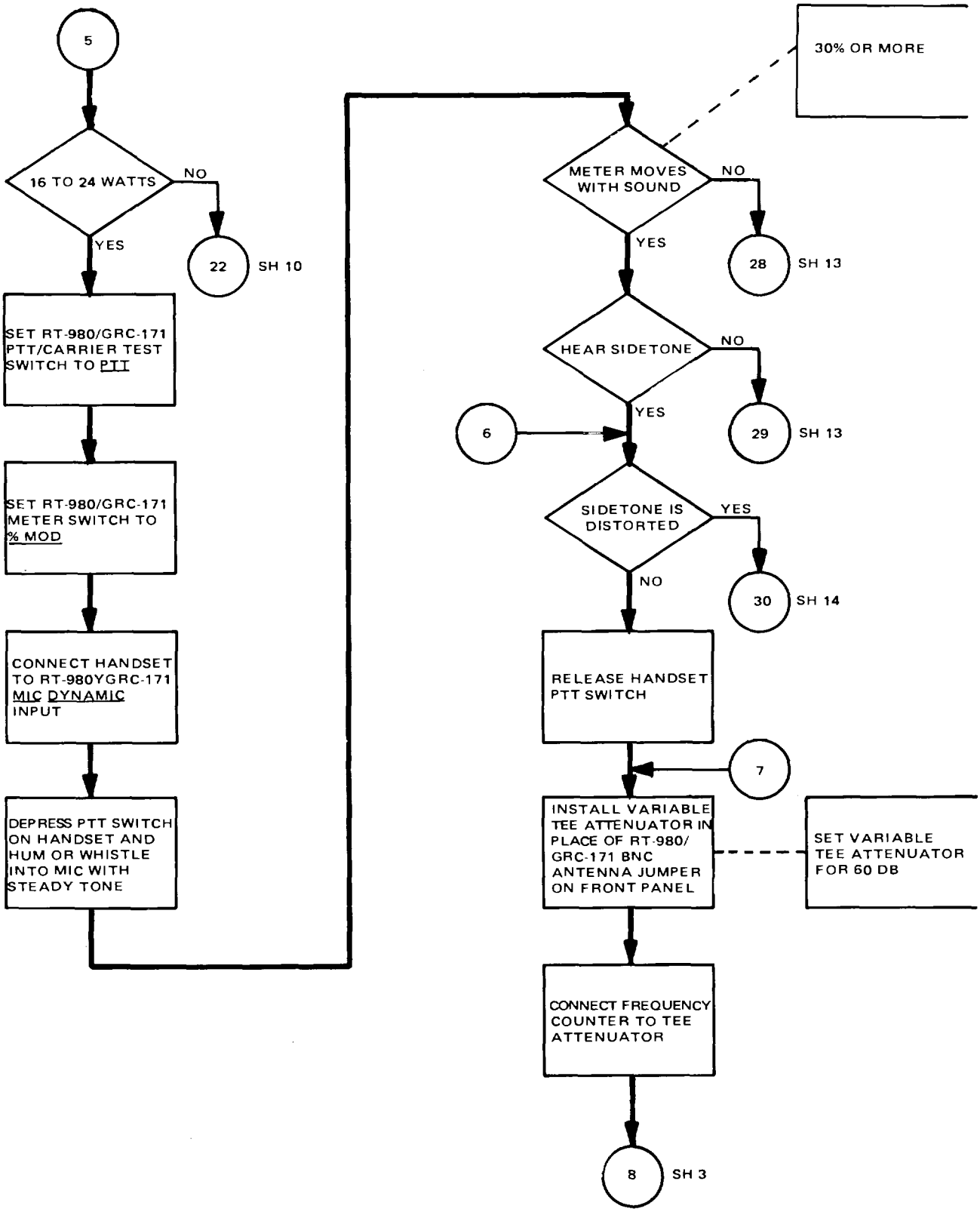


Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 2 of 17)

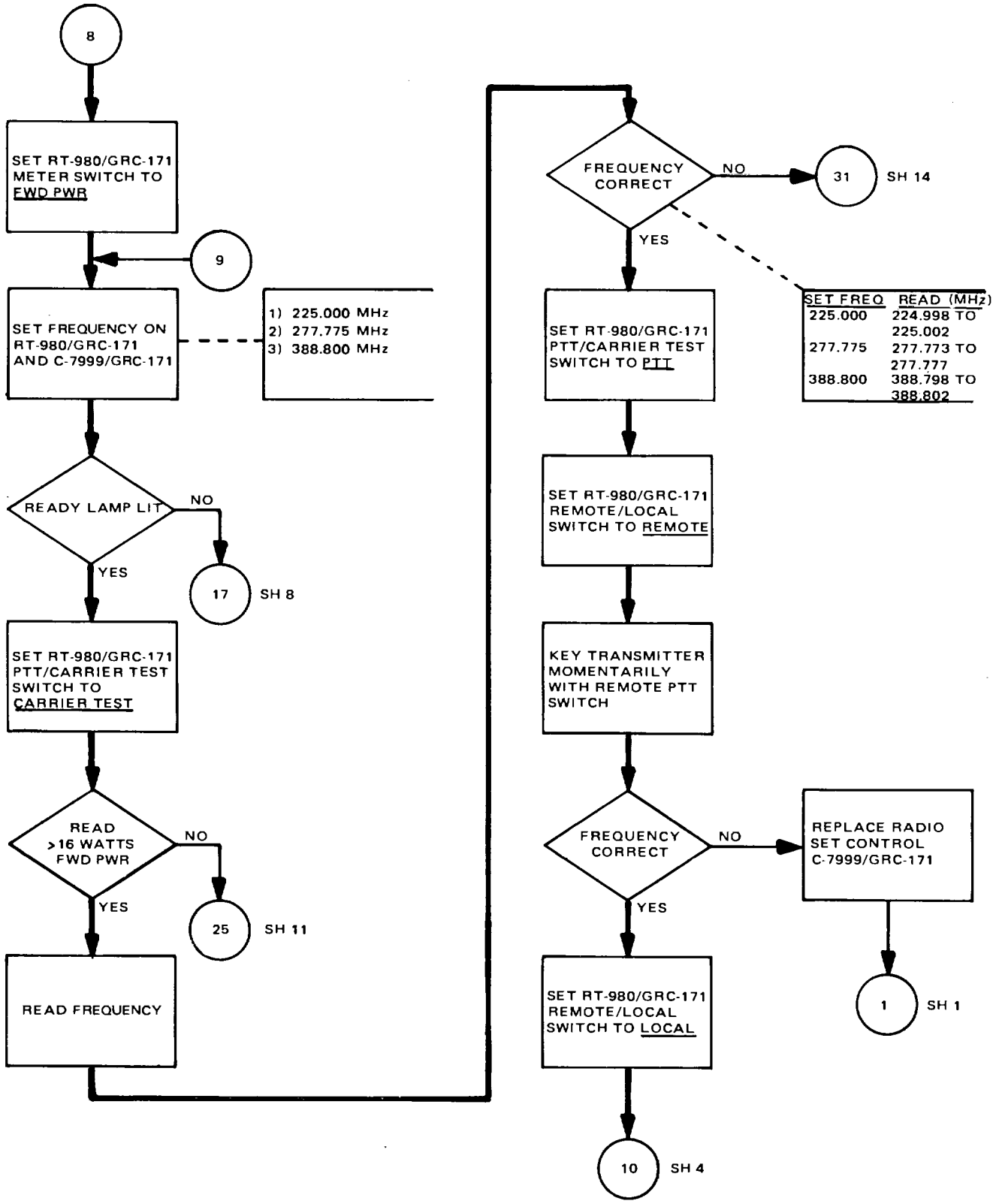


Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 3 of 17) 5-32

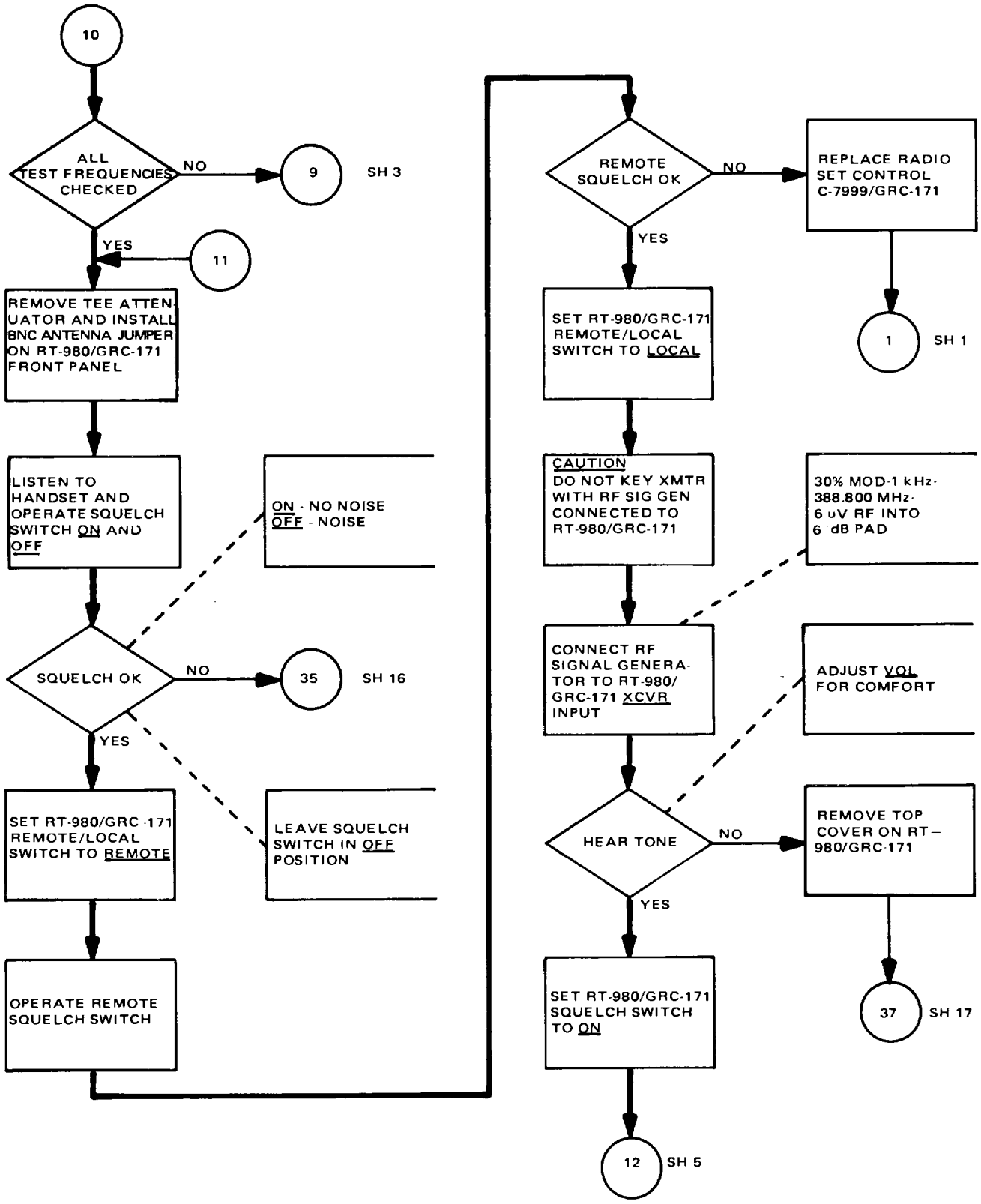


Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 4 of 17)

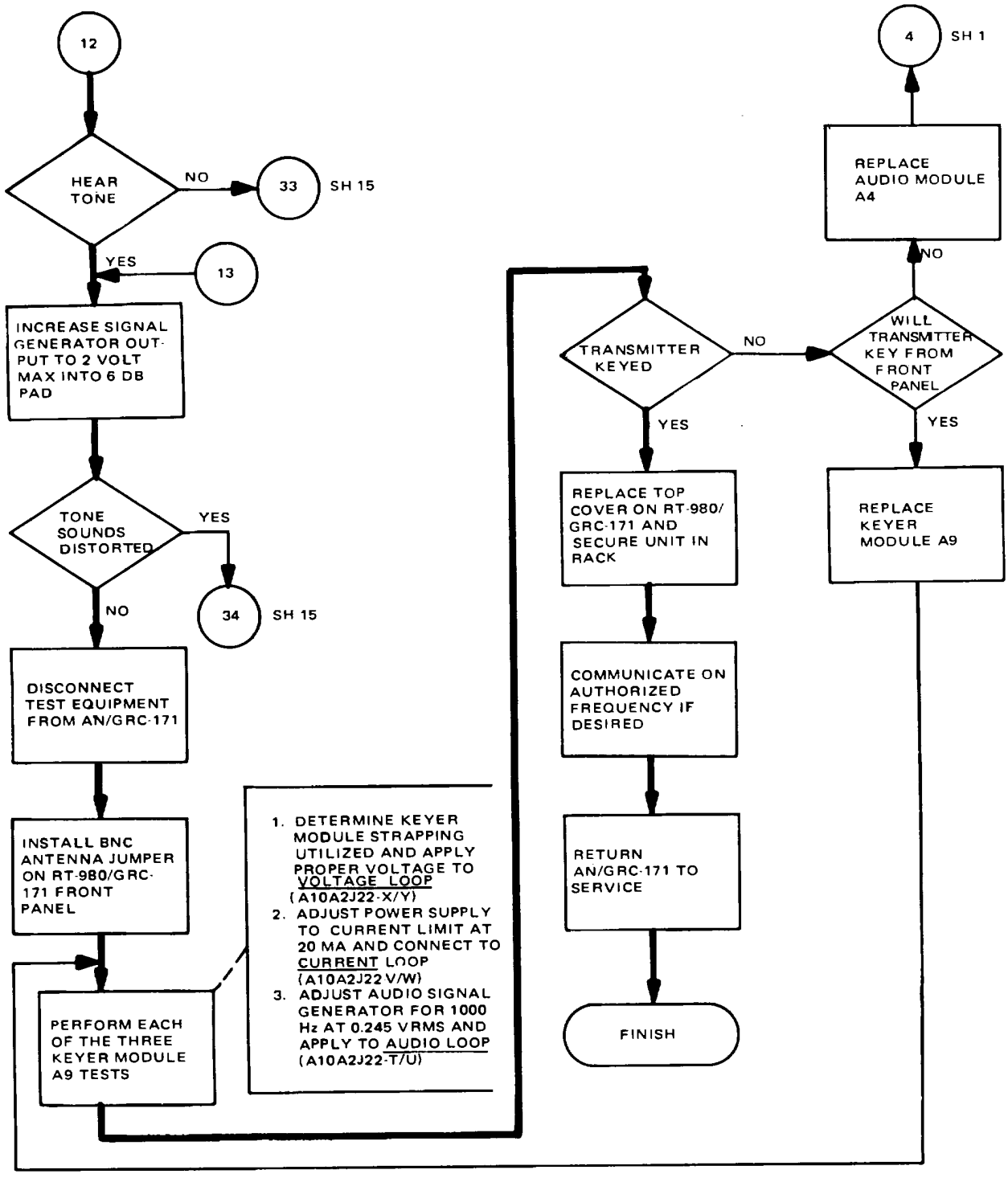

12
HEAR TONE
NO
33
SH 15
YES
13
INCREASE SIGNAL GENERATOR OUTPUT TO 2 VOLT MAX INTO 6 DB PAD
TONE SOUNDS DISTORTED
YES
34
SH 15
NO
DISCONNECT TEST EQUIPMENT FROM AN/GRC-171
INSTALL BNC ANTENNA JUMPER ON RT-980/GRC-171 FRONT PANEL
PERFORM EACH OF THE THREE KEYER MODULE A9 TESTS
1. DETERMINE KEYER MODULE STRAPPING UTILIZED AND APPLY PROPER VOLTAGE TO VOLTAGE LOOP (A10A2J22-X/Y)
2. ADJUST POWER SUPPLY TO CURRENT LIMIT AT 20 MA AND CONNECT TO CURRENT LOOP (A10A2J22 V/W)
3. ADJUST AUDIO SIGNAL GENERATOR FOR 1000 Hz AT 0.245 VRMS AND APPLY TO AUDIO LOOP (A10A2J22-T/U)
TRANSMITTER KEYED
NO
YES
WILL TRANSMITTER KEY FROM FRONT PANEL
YES
NO
4
SH 1
REPLACE AUDIO MODULE A4
REPLACE TOP COVER ON RT-980/GRC-171 AND SECURE UNIT IN RACK
REPLACE KEYER MODULE A9
COMMUNICATE ON AUTHORIZED FREQUENCY IF DESIRED
RETURN AN/GRC-171 TO SERVICE
FINISH

Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 5 of 17)

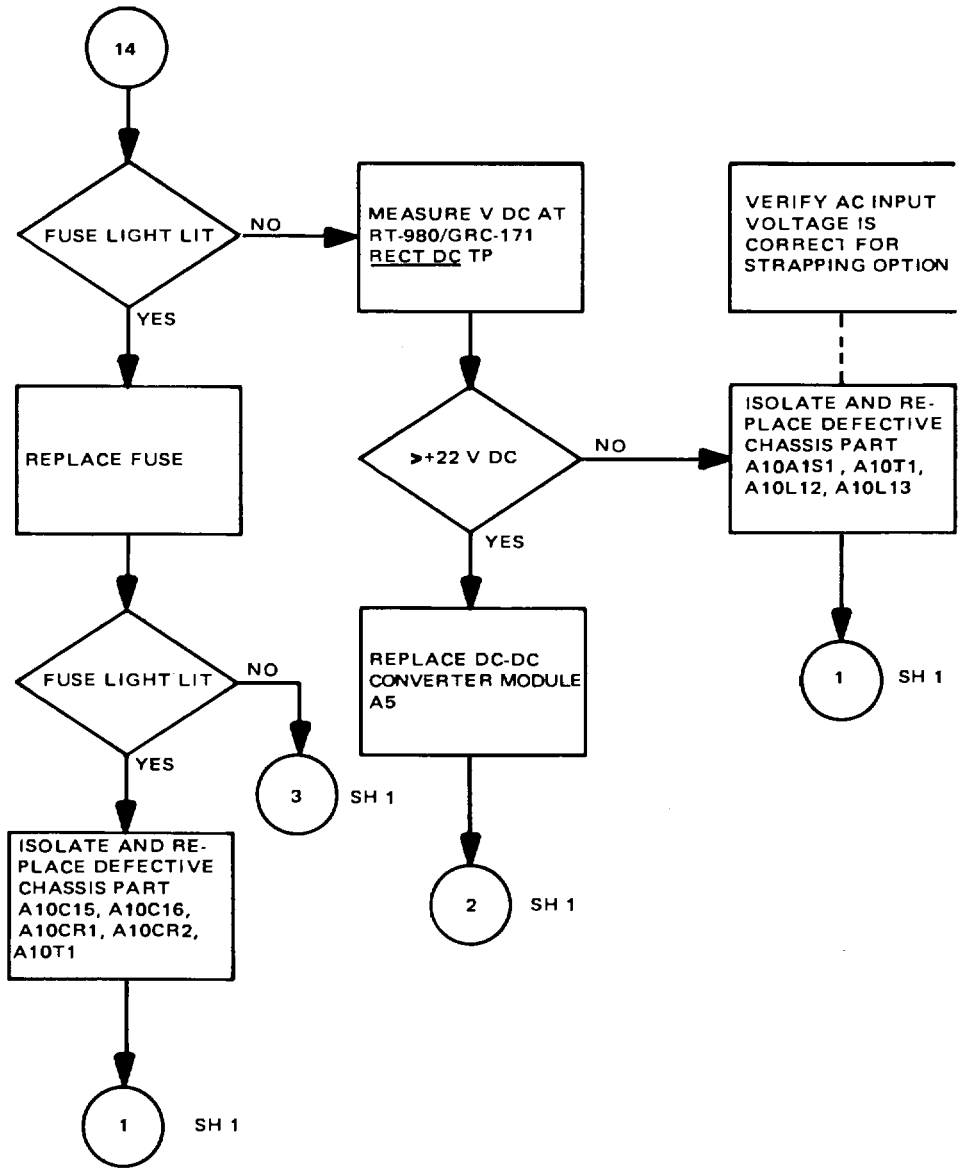


Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 6 of 17)

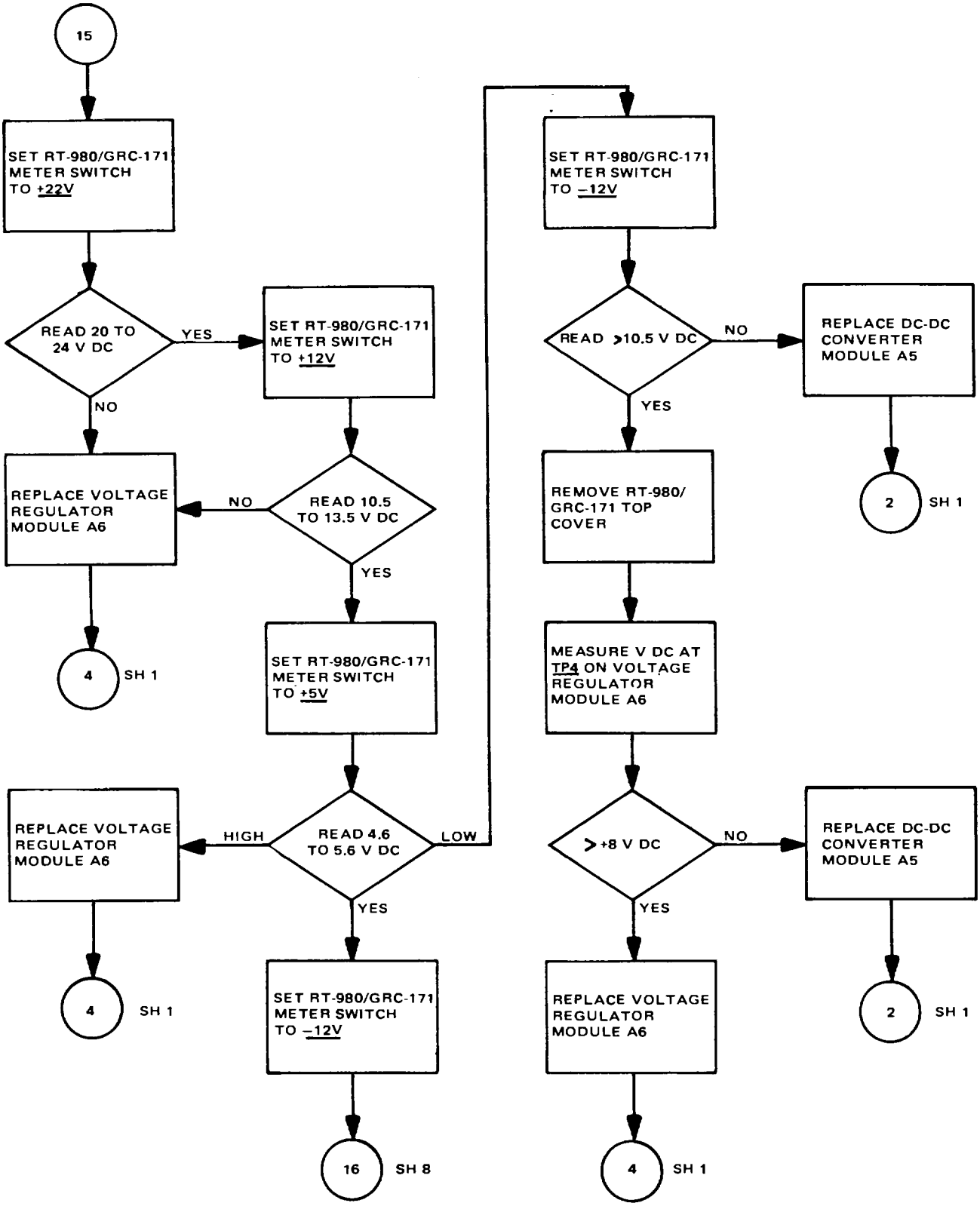


Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 7 of 17)

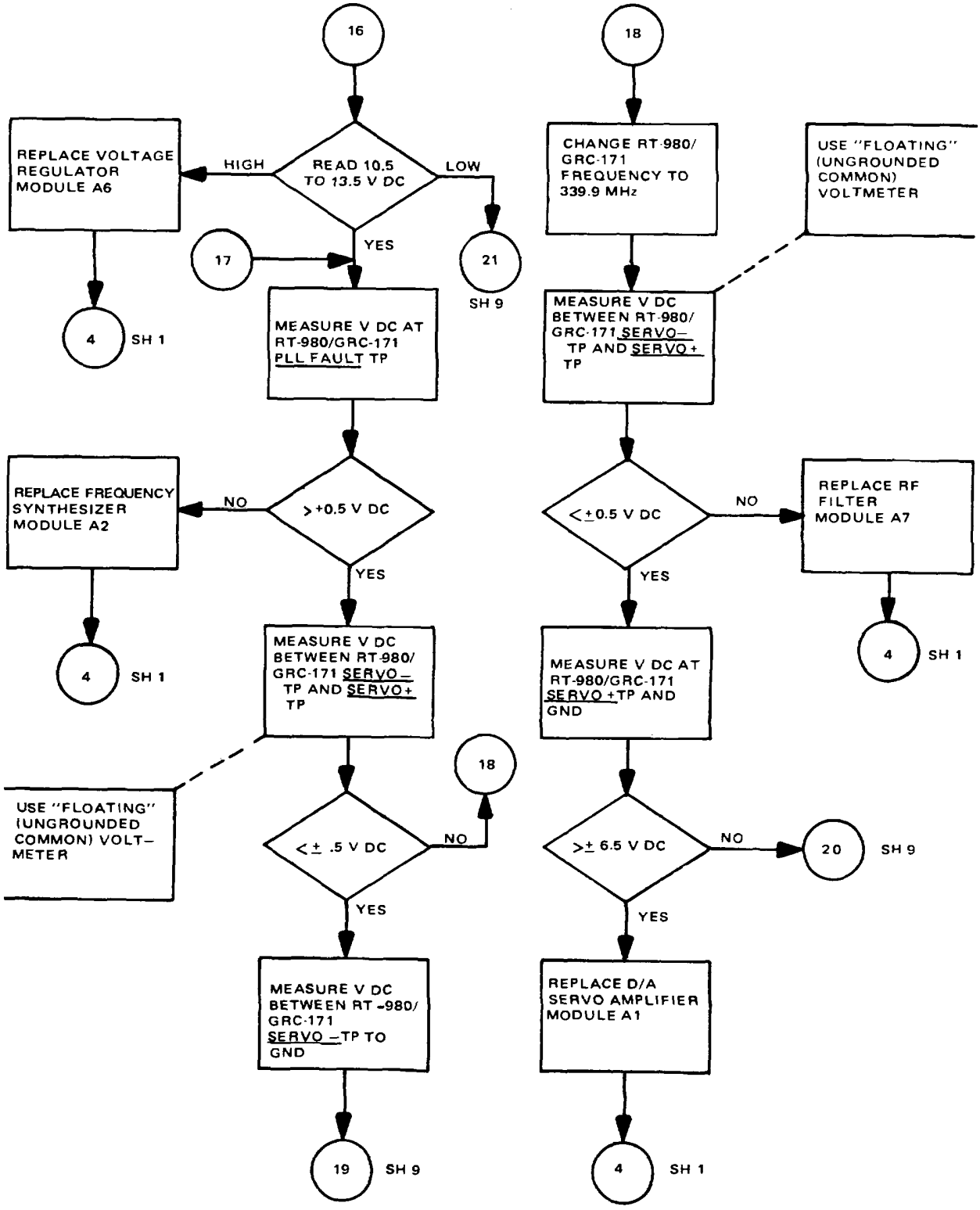


Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 8 of 17)

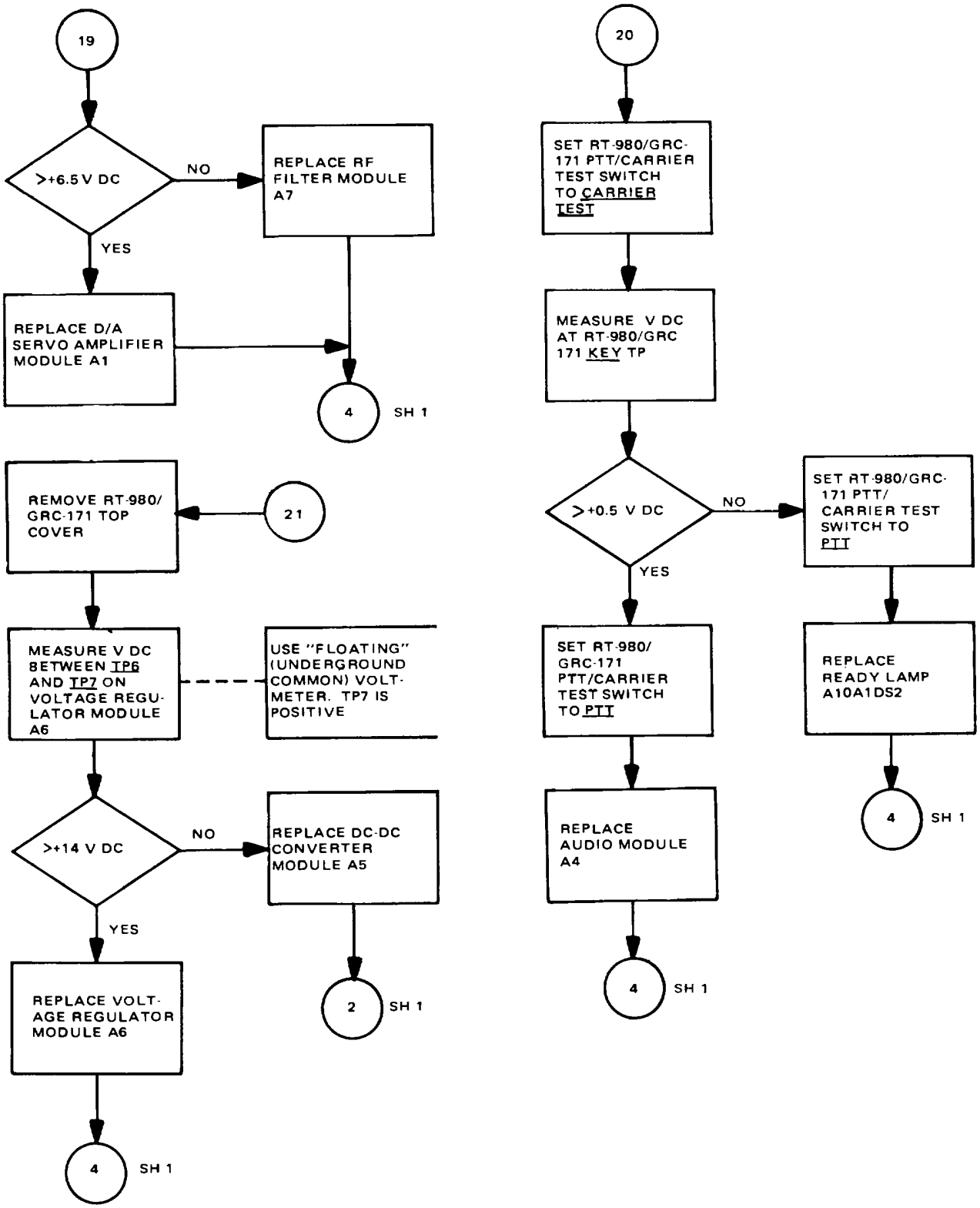


Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 9 of 17)

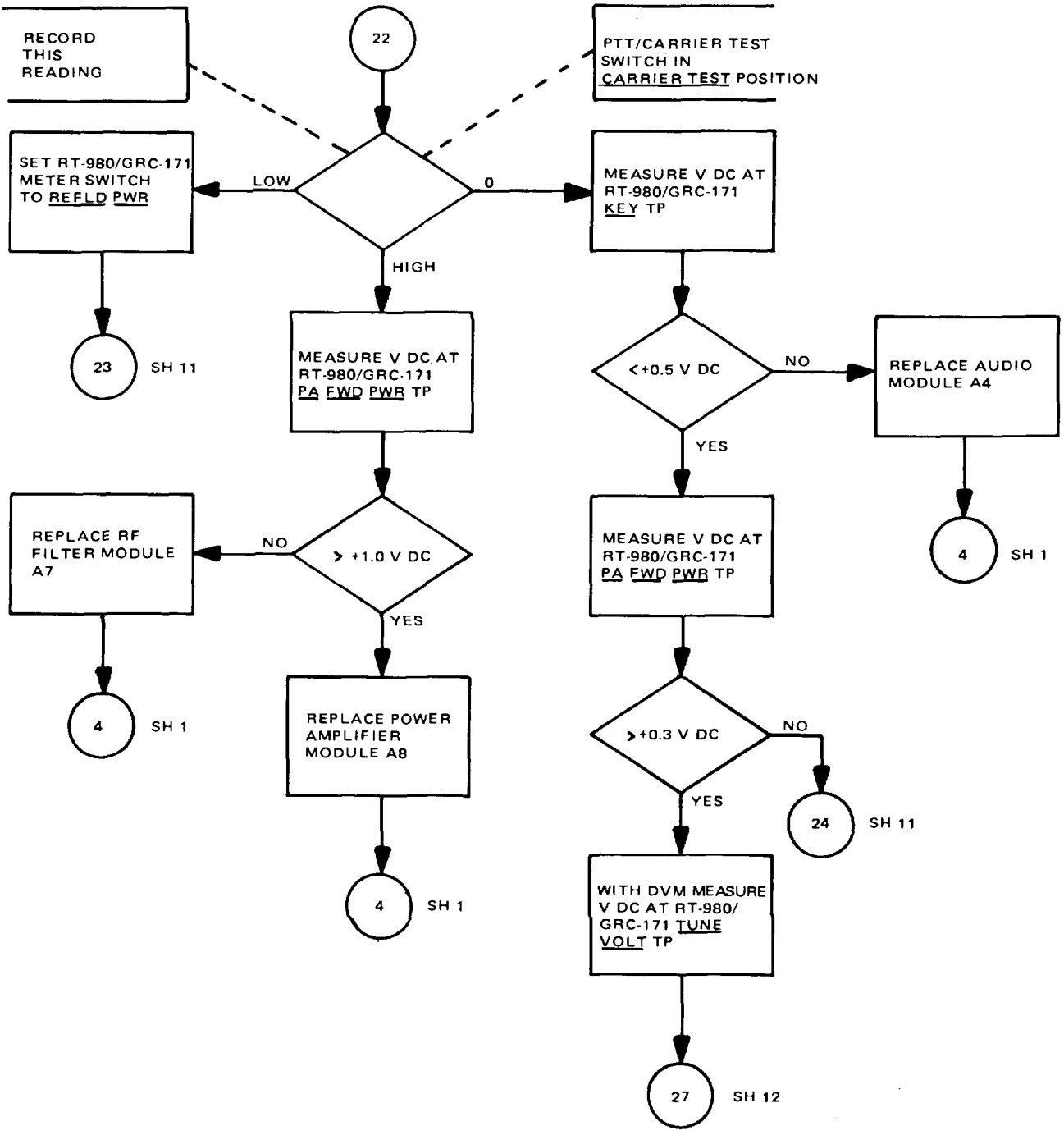


Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 10 of 17)

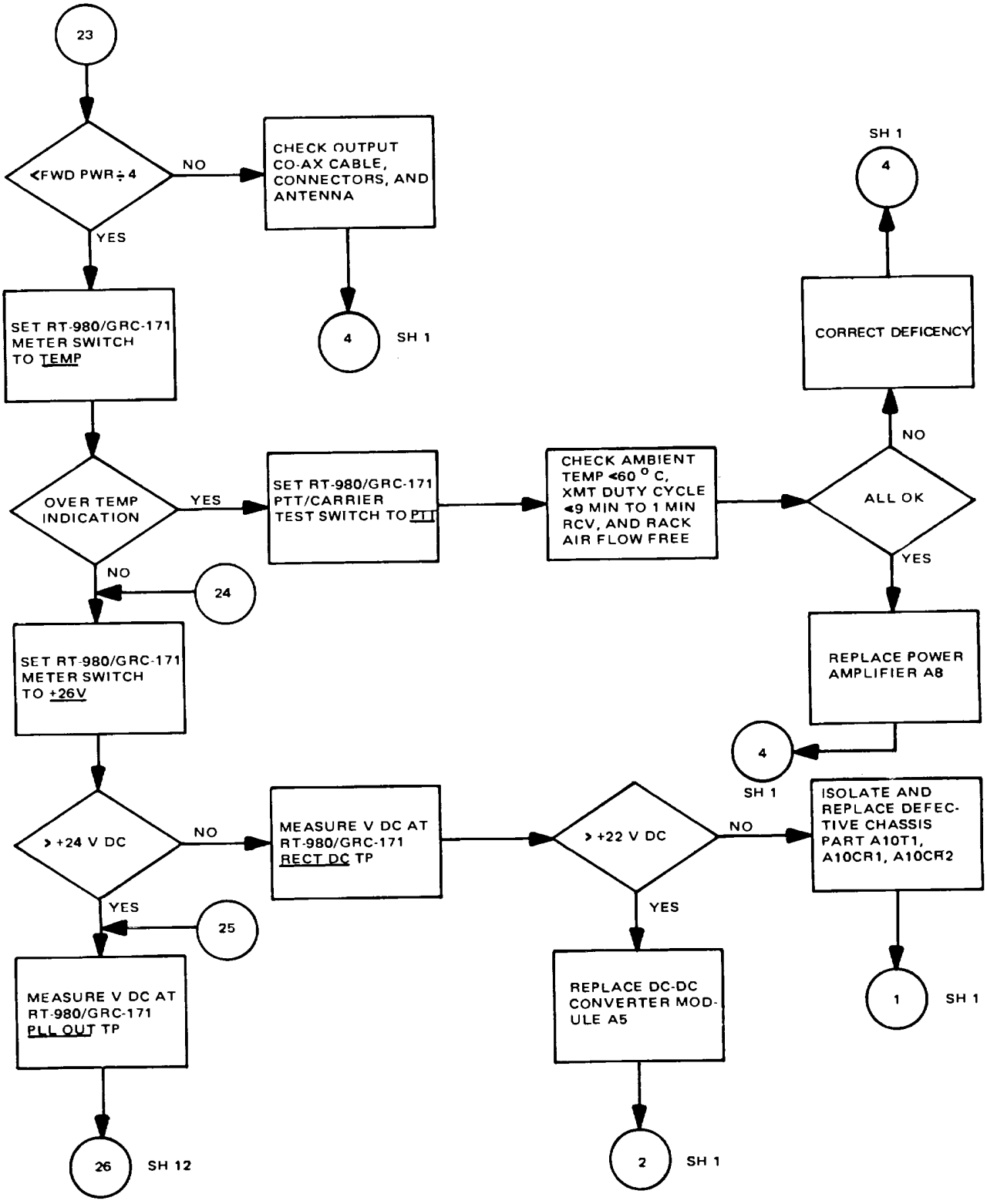


Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 11 of 17)

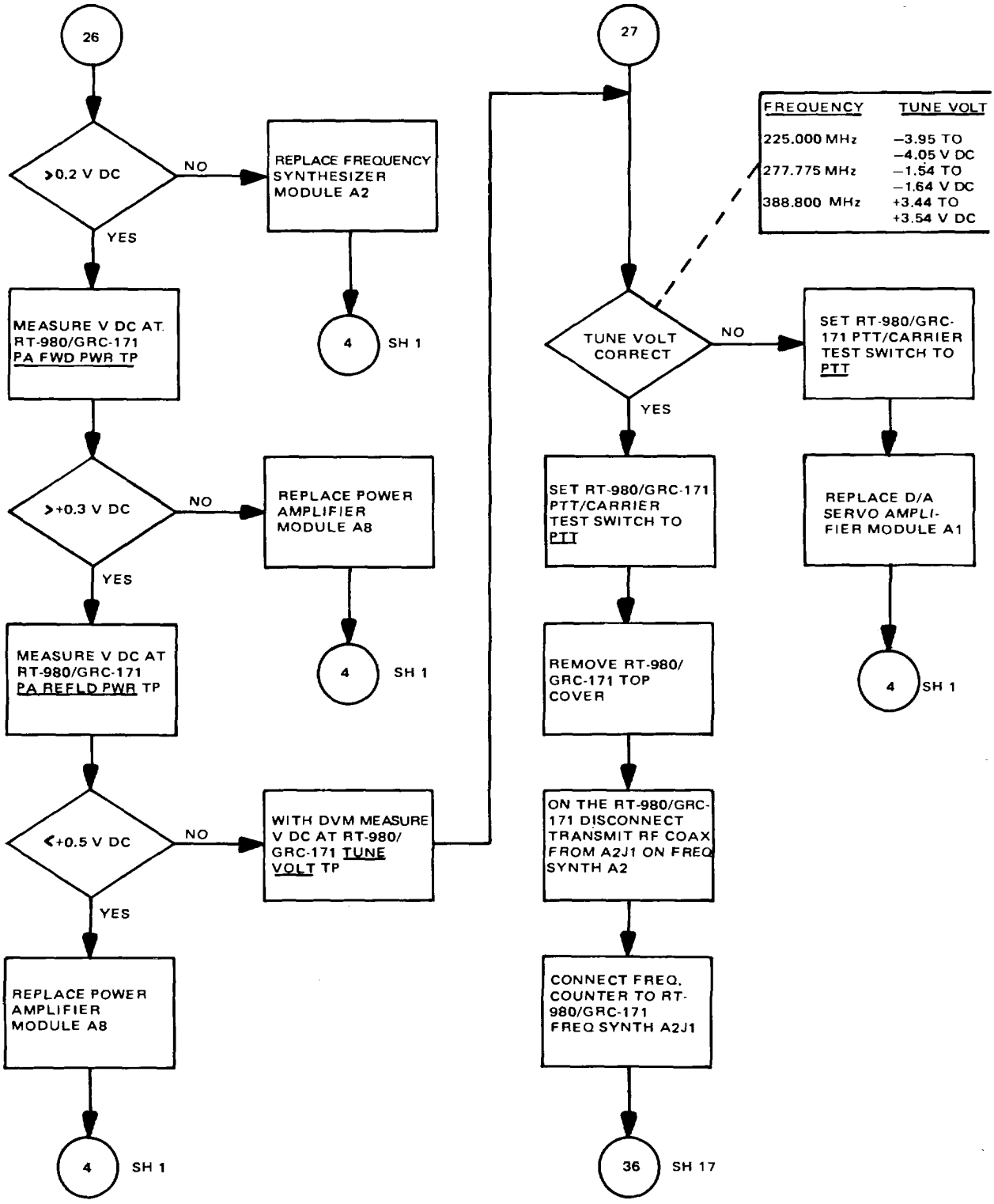


Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 12 of 17)

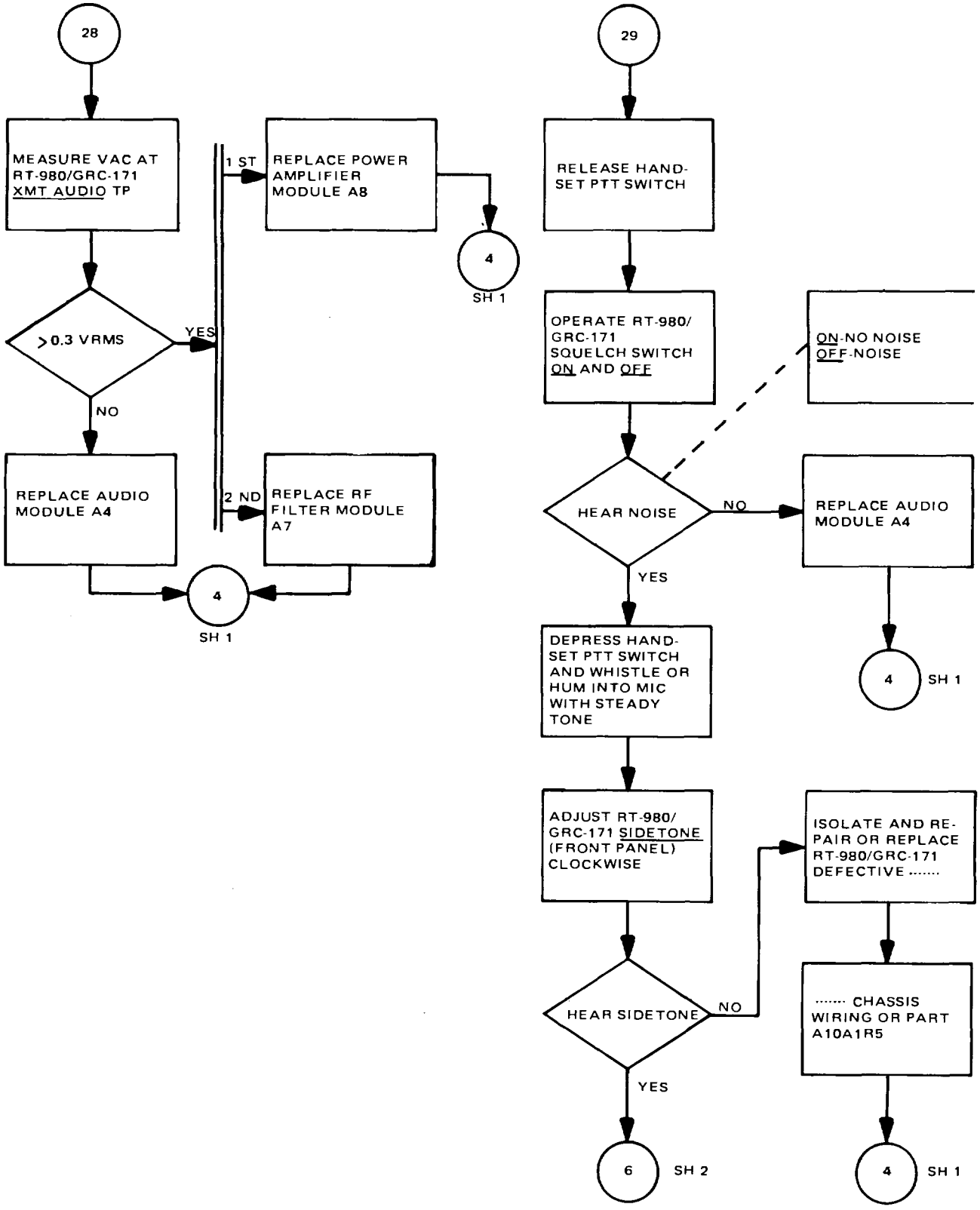


Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 13 of 17)

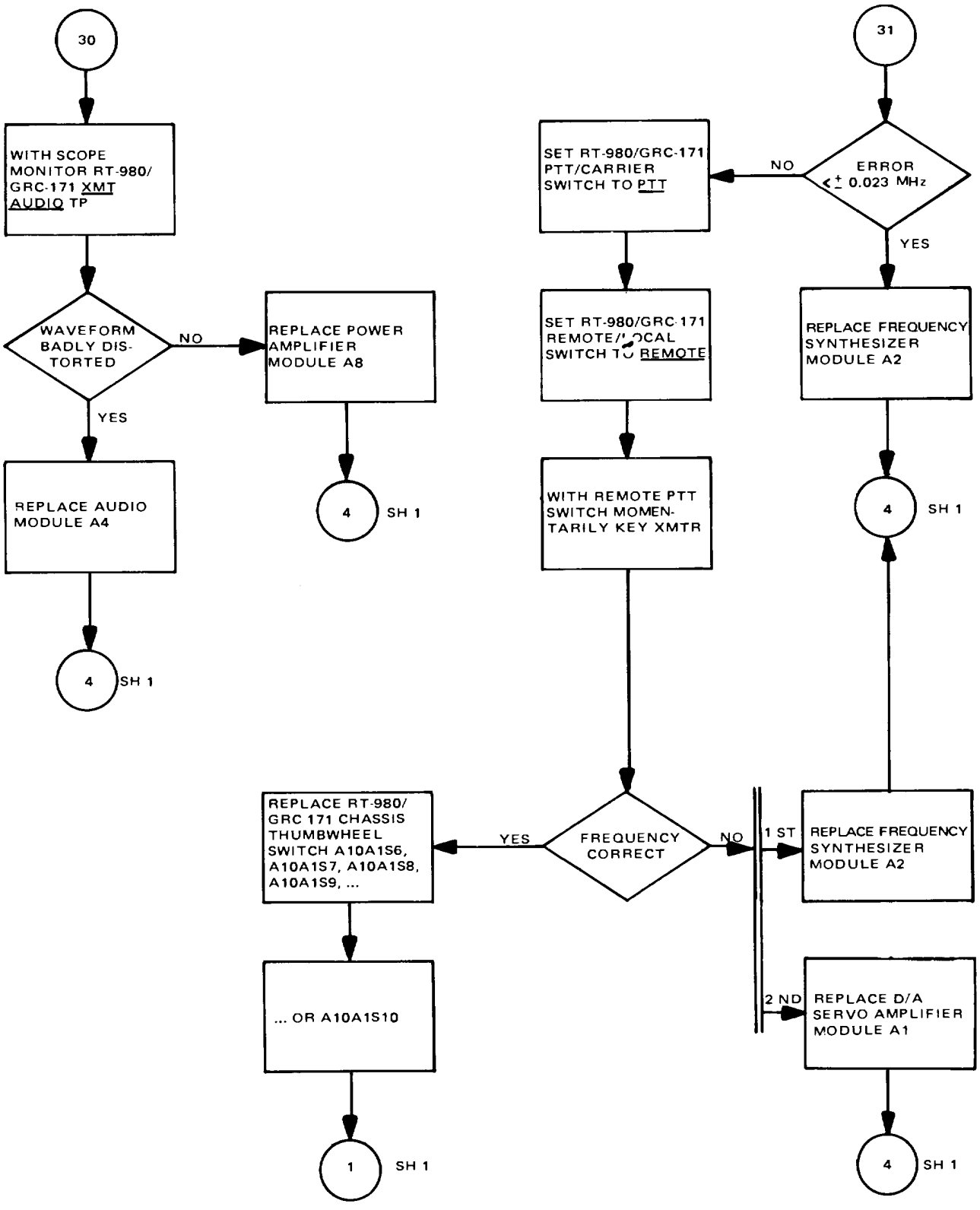


Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 14 of 17)

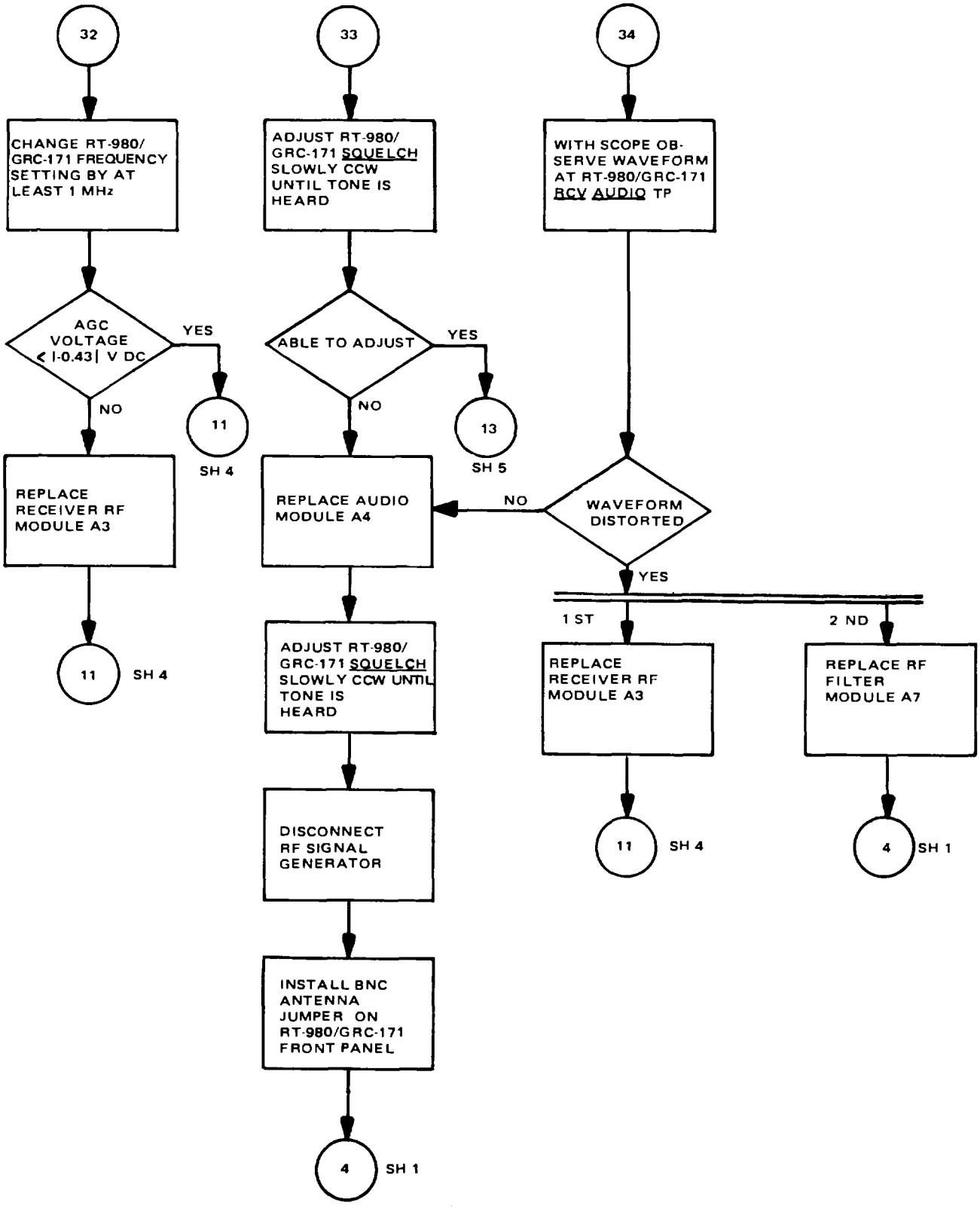


Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 15 of 17)

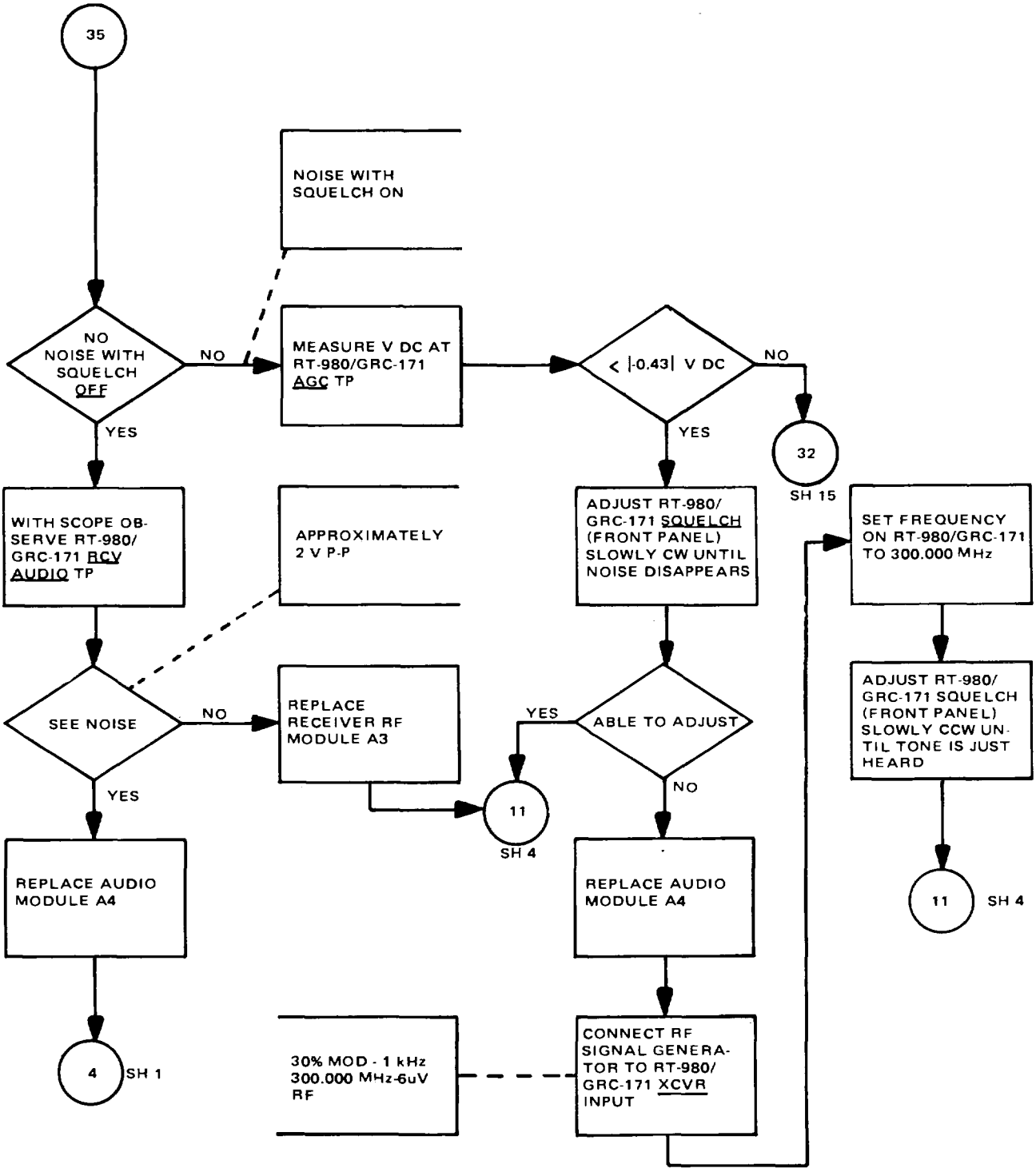


Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 16 of 17)

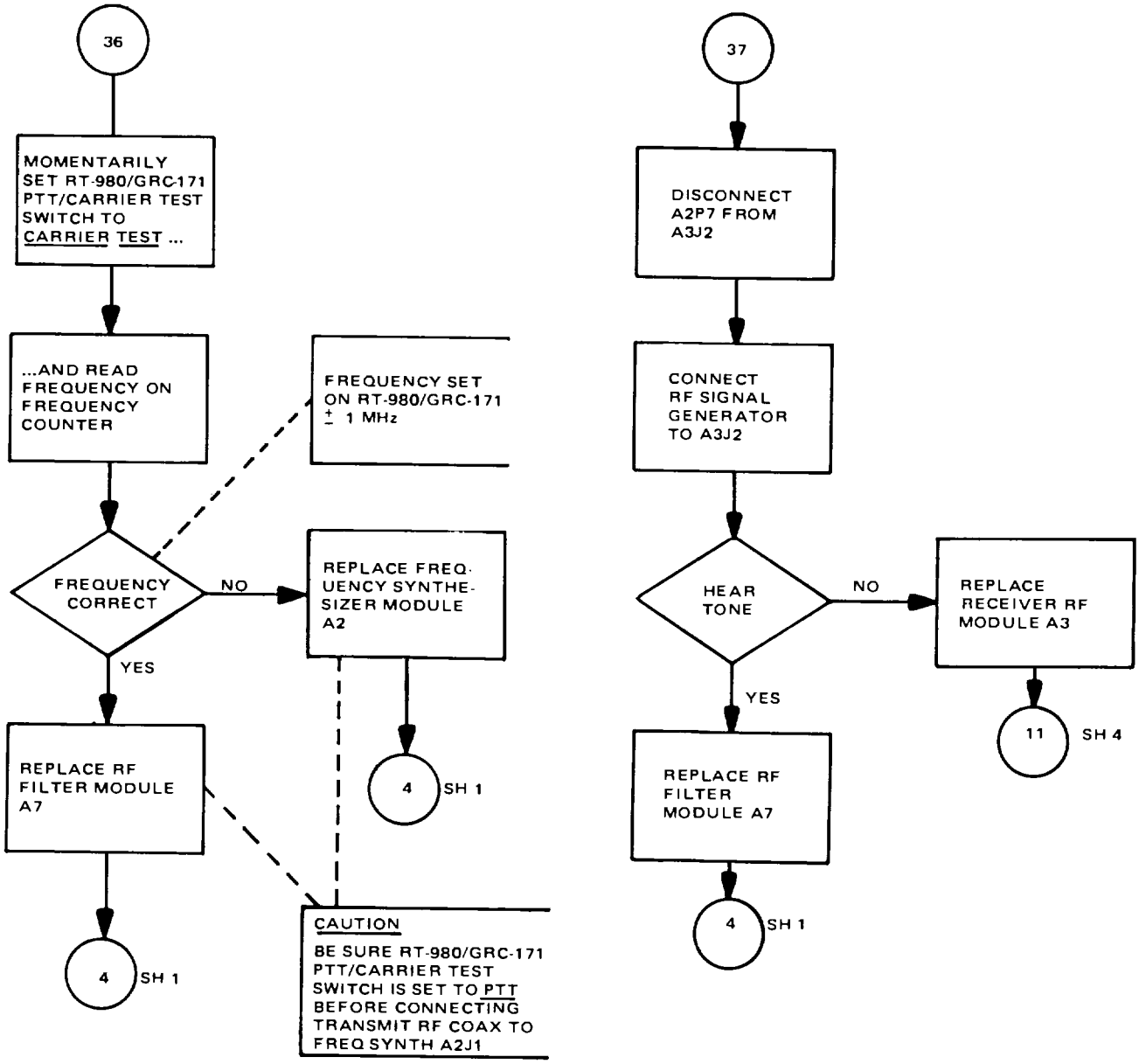

36
MOMENTARILY SET RT-980/GRC-171 PTT/CARRIER TEST SWITCH TO CARRIER TEST ...
...AND READ FREQUENCY ON FREQUENCY COUNTER
FREQUENCY SET ON RT-980/GRC-171 ± 1 MHz
FREQUENCY CORRECT
NO
YES
REPLACE FREQ-UENCY SYNTHE-SIZER MODULE A2
4 SH 1
REPLACE RF FILTER MODULE A7
4 SH 1
CAUTION
BE SURE RT-980/GRC-171 PTT/CARRIER TEST SWITCH IS SET TO PTT BEFORE CONNECTING TRANSMIT RF COAX TO FREQ SYNTH A2J1
37
DISCONNECT A2P7 FROM A3J2
CONNECT RF SIGNAL GENERATOR TO A3J2
HEAR TONE
NO
YES
REPLACE RECEIVER RF MODULE A3
11 SH 4
REPLACE RF FILTER MODULE A7
4 SH 1

Figure 5-9. Radio Set AN/GRC-171 Troubleshooting Procedures (Sheet 17 of 17)

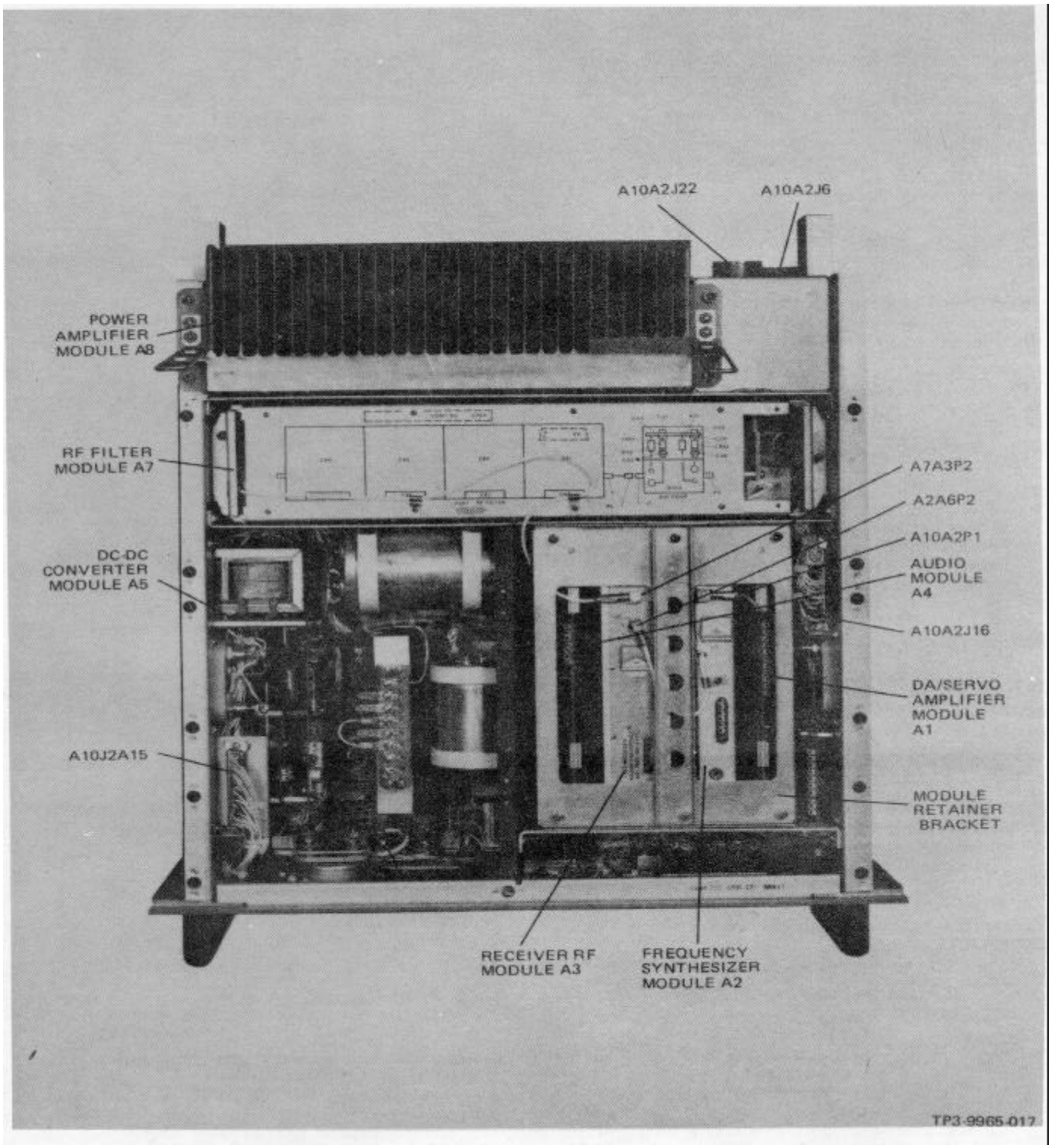


Figure 5-10. RT-980/GRC-171 Module Location, Top View

5-27. RECEIVER RF MODULE A3. 5-28.

5-28. REMOVAL OF MODULE. To remove receiver rf module A3 from chassis, refer to figure 5-10 and proceed as follows:

a. Remove top cover.
b. Loosen six captive screws around periphery of module retainer bracket and remove bracket.
c. Disconnect receive injection cable A2P2 from A3J1 and receive rf cable A7A3P2 from A3J2.
d. Remove module by carefully sliding module to the rear, disengaging A3A1P1 from A10OA2J12, and lifting module from chassis.

5-29. REPLACEMENT OF MODULE. Replace module in the reverse order of its removal.

CAUTION

Ensure proper module-to-chassis plug and pin alignment is achieved before sliding module into position. Do not exert abnormal force to seat module.

5-30. AUDIO MODULE A4.

5-31. REMOVAL OF MODULE. To remove audio module A4 from chassis, refer to figure 5-10 and proceed as follows:

a. Remove top cover.
b. Loosen six captive screws around periphery of module retainer bracket and remove bracket.
c. Disconnect receive rf cable A7A3P2 from A3J2.
d. Remove module by carefully sliding module to the rear, disengaging A4P1 from A10OA2J13, and lifting module from chassis.

5-32. REPLACEMENT OF MODULE. Replace module in the reverse order of its removal.

CAUTION

Ensure proper module-to-chassis plug and pin alignment is achieved before sliding module into position. Do not exert abnormal force to seat module.

5-33. DC-DC CONVERTER MODULE A5.

5-34. REMOVAL OF MODULE. To remove module from chassis, refer to figures 5-10 and 5-11 and proceed as follows:

a. Remove top cover.
b. Loosen two captive screws on AlOA2J15 and carefully disengage AlOA2J15 from A5P1.
c. Loosen ten captive screws around periphery of module.
d. Remove module from chassis.

5-35. REPLACEMENT OF MODULE. Replace module in the reverse order of its removal.

CAUTION

Ensure proper module-to-chassis plug and pin alignment is achieved before tightening the captive screws on the chassis plug. Do not exert abnormal force to seat plug.

5-36. VOLTAGE REGULATOR MODULE A6.

5-37. REMOVAL OF MODULE. To remove module from chassis, refer to figures 5-10 and 5-12 and proceed as follows:

a. Remove top cover.
b. Loosen two captive screws on A10OA2J16 and carefully disengage A10OA2J16 from A6P1.
c. Loosen ten captive screws around periphery of module.
d. Remove module from chassis.

5-38 REPLACEMENT OF MODULE.. Replace module in the reverse order of its removal.

CAUTION

Ensure proper module-to-chassis plug and pin alignment is achieved before tightening the captive screws on the chassis plug. Do not exert abnormal force to seat plug.

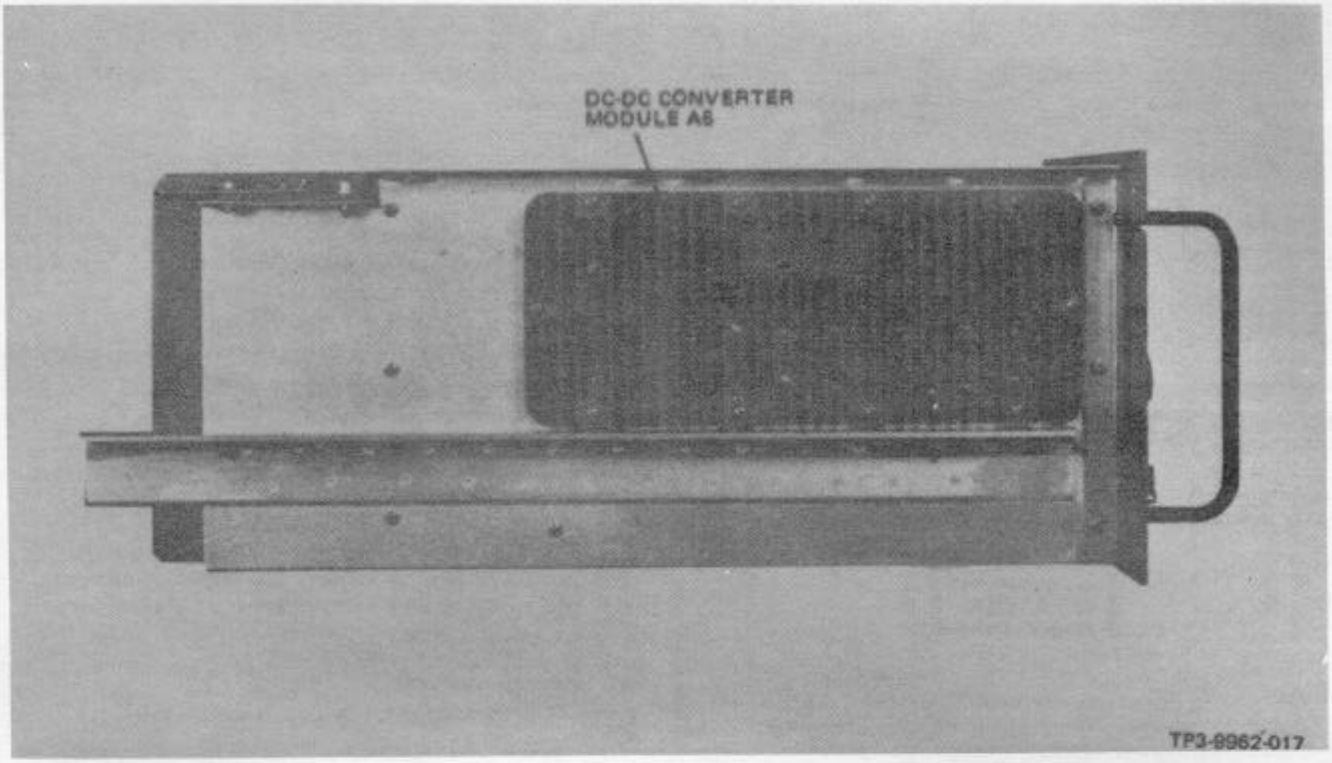


Figure 5-11. RT-980/GRC-171 Module Location, Left Side

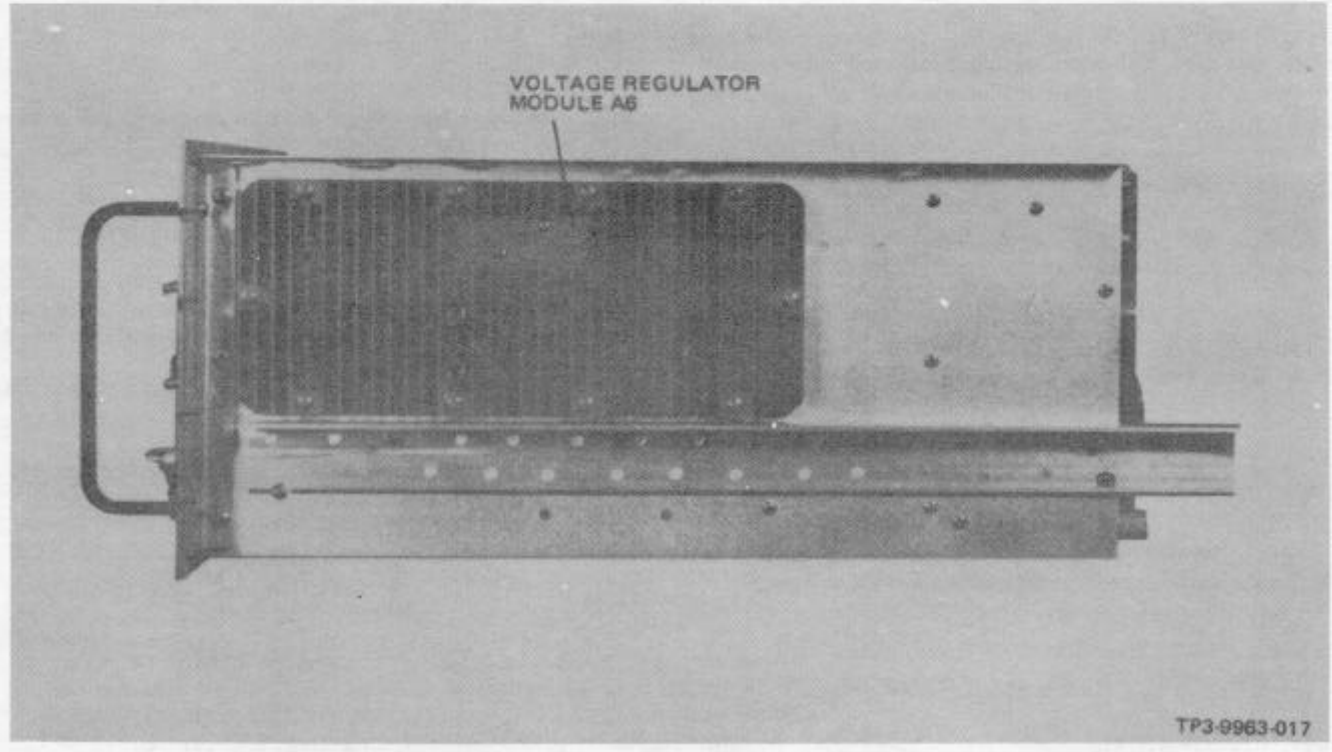


Figure 5-12. RT-980/GRC-171 Module Location, Left Side

5-39. RF FILTER MODULE A7.

5-40. REMOVAL OF MODULE. To remove module from chassis, refer to figure 5-10 and proceed as follows:

a. Remove top cover.

b. Remove screw from top. rear left corner of module and screw from top, right edge of module.

c. Disconnect receiver rf cable connector A7A3P2 from A3J2.

d. Remove module from chassis by carefully lifting module up and disengaging module plugs from chassis jack.

5-41. REPLACEMENT OF MODULE. Replace module in the reverse order of ifs removal.

CAUTION

Ensure proper module-to-chassis plug and pin alignment is achieved before seating module into position. Do not exert abnormal force to seat module.

5-42. POWER AMPLIFIER MODULE A8.

5-43. REMOVAL OF MODULE. To remove module from chassis, refer to figure 5-10 and proceed as follows:

a. Remove top cover.

b. Loosen four captive screws on corners of module.

c. Remove module from chassis by carefully lifting module up and disengaging module plugs from chassis jacks.

5-44. REPLACEMENT OF MODULE. Replace module in the reverse order of its removal.

CAUTION

Ensure proper module-to-chassis plug and pin alignment is achieved before seating module into position. Do not exert abnormal force to seat module.

5-45. KEYER MODULE A9

5-46. REMOVAL OF MODULE. To remove module from chassis, refer to figures 5-10 and 5-13 and proceed as follows:

a. Remove top cover.

b. Remove d/a servo amplifier module A1 (paragraph 5-21).

c. Remove frequency synthesizer module A2 (paragraph 5-24).

d. Remove module from chassis by carefully sliding module forward, disengaging A9P1 from AlOA2J14, and lifting module from chassis.

5-47. REPLACEMENT OF MODULE. Replace module in the reverse order of its removal.

CAUTION

Ensure proper module-to-chassis plug and pin alignment is achieved before seating module in to position. Do not exert abnormal force to seat module.

5-48. FRONT PANEL (P/O CHASSIS A10).

5-49. REMOVAL OF PANEL. To remove front panel from chassis, proceed as follows:

a. Disconnect antenna/transceiver U-shaped connector from ANT and XCVR jacks (AlOW2J1/ A10W3J2).

b. Remove three screws from forward, left side of chassis and three screws from forward, right side of chassis.

c. Remove five screws from bottom edge of front panel.

d. Remove three screws from center of front panel (two screws behind TEST POINT access door).

e. Front panel can now be brought forward and laid face down.

5-50. REPLACEMENT OF PANEL. Replace front panel in the reverse order of its removal.

CAUTION

Do not place excessive strain on inter-connecting cabling and wiring during removal and replacement of front panel. Ensure interconnecting cabling and wiring is not pinched between chassis and front panel during installation of front panel.

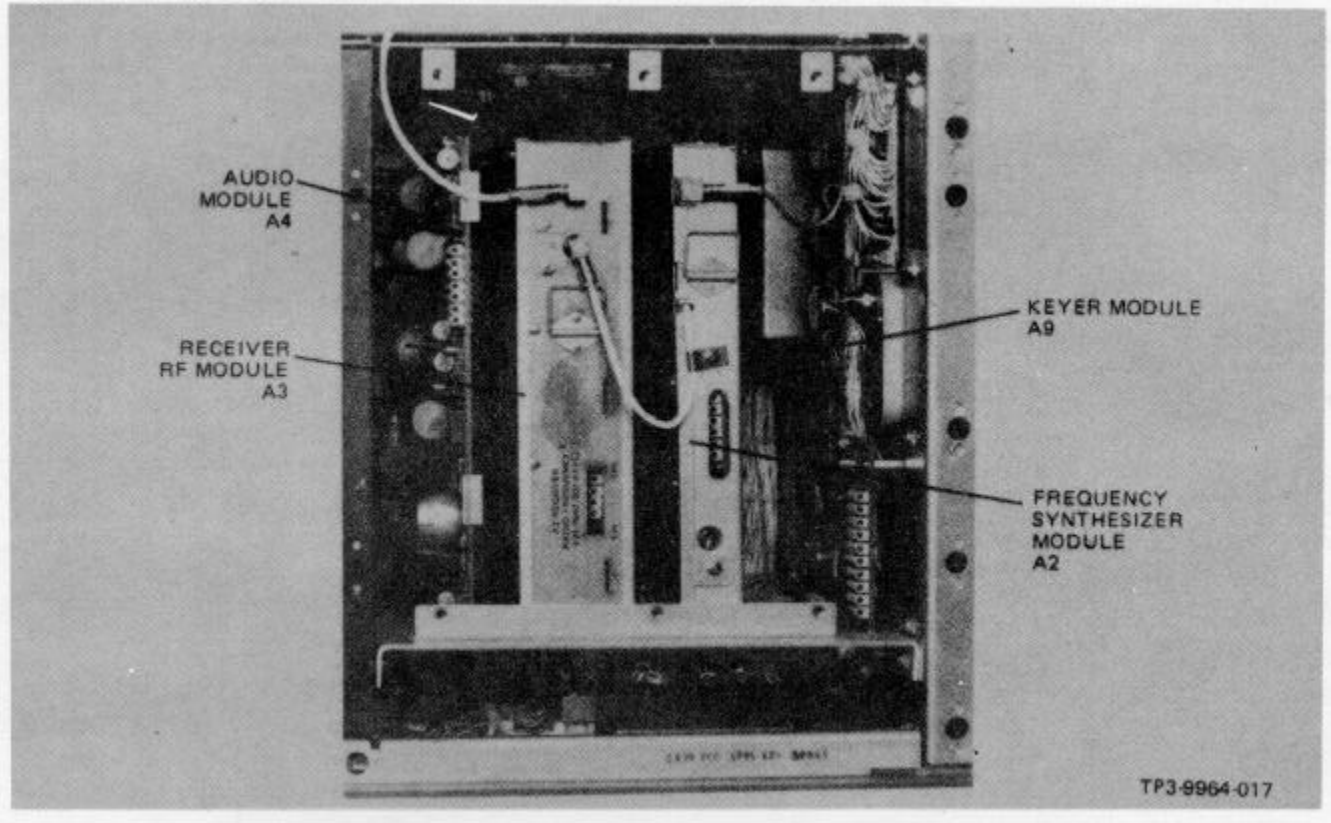


Figure 5-13. RT-980/GRC-171 Module Location, Top View Partial

SECTION II

SPECIAL MAINTENANCE

(To Be Supplied)

CHAPTER 6

CIRCUIT DIAGRAMS

6-1. GENERAL.

6-2. The purpose of these diagrams is to assist the technician in understanding the component makeup and circuit arrangement in the equipment. The diagrams furnish the technician with visual assistance for tracing continuity and trouble analysis and provide a reference during maintenance work on the equipment. General information pertaining to individual diagrams is included in the form of notes on the face of each diagram.

6-3. EFFECTIVITIES.

6-4. Each equipment, unit, and assembly provided is marked with a manufacturing alphabetic identifier in addition to the basic part number. The alphabetic identifier will be preceded by the letters REV (revision) and will start with 0 if no changes have been processed. The first change will be identified as A, the second as B, and continuing through Z to AA, and ultimately to ZZ. Because minor electrical and/or mechanical differences exist between various re-visions, where applicable, an effectivity-versus-re-vision identifier cross-reference is provided on the schematic diagram.

Each effectivity applies to a group of revision identifiers and is indicated by a key (C<) on both the effectivity table and the appropriate schematic diagram.

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By Order of the Secretaries of the Army, the Navy, and the Air Force:

JOHN A. WICKHAM, JR.
General, United States Army
Chief of Staff

Official:

ROBERT M. JOYCE
Major General, United States Army
The Adjutant General

G. B. SHICK
Rear Admiral United States Navy
Commander, Naval Electronic
Systems Command

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Chief of Staff

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General, USAF, Commander, Air Force
Logistics Command

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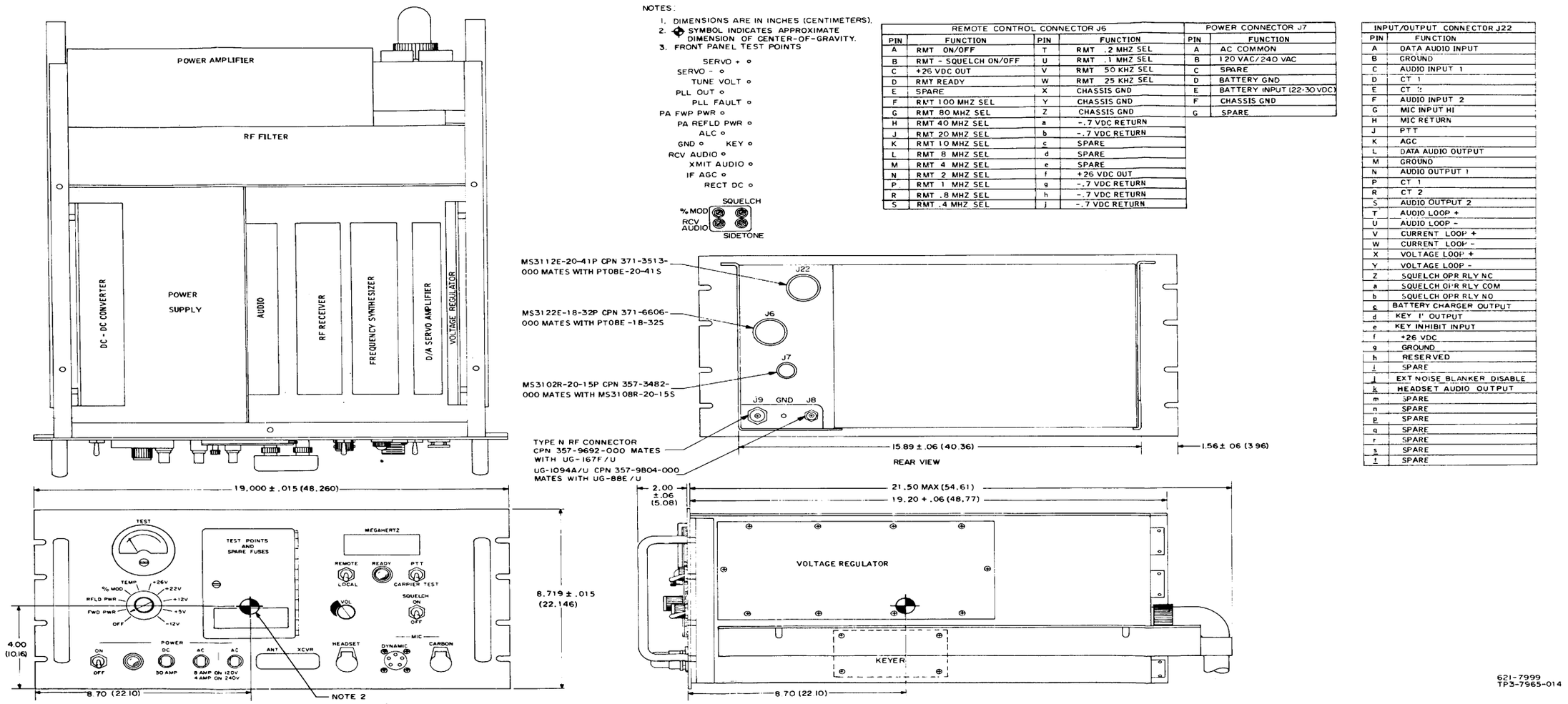
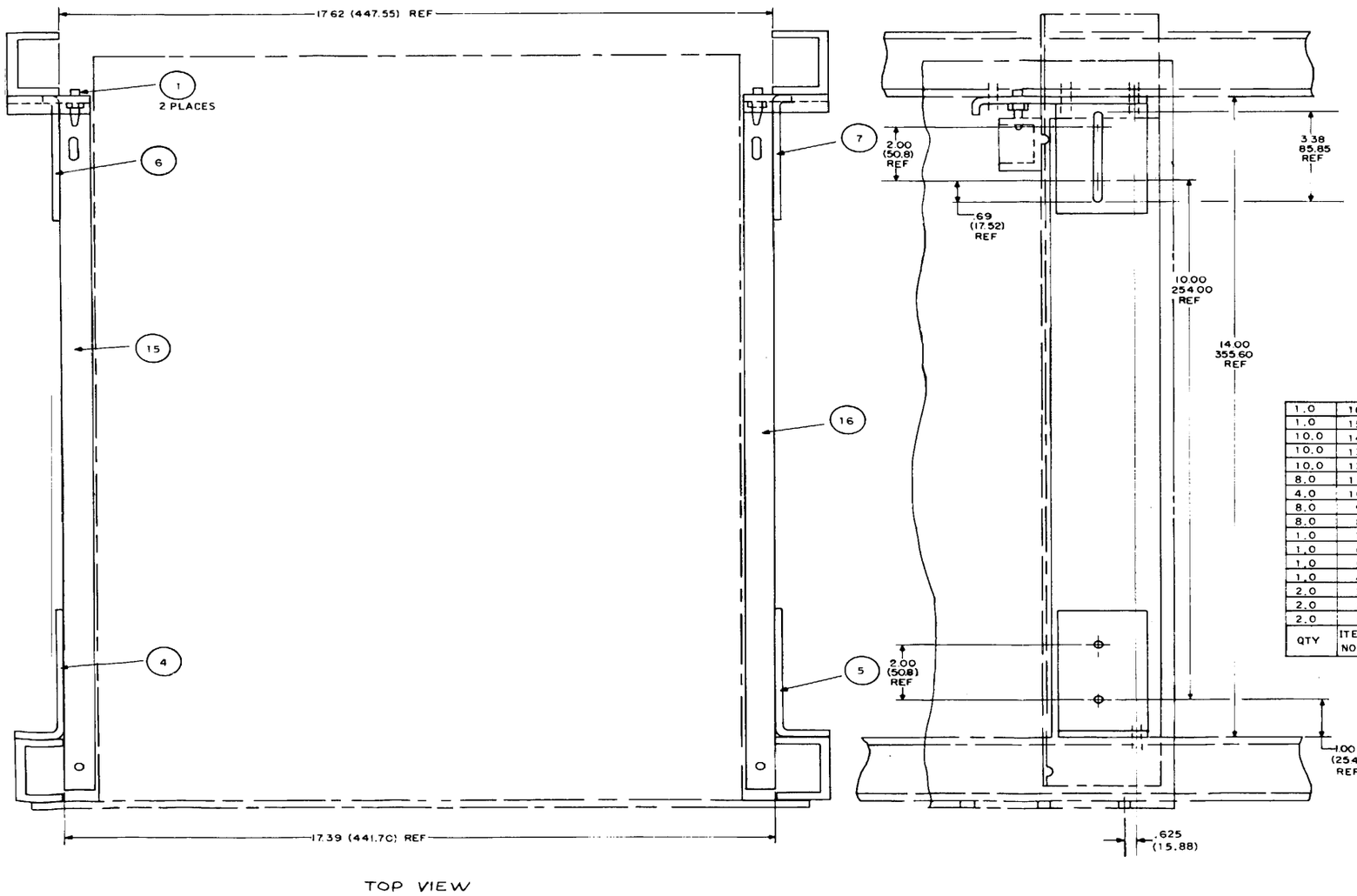


Figure FO-1. Radio Receiver Transmitter RT-980/grc-171, Outline and Mounting Dimensions Diagram (Sheet 1 of 2)



QTY	ITEM NO.	PART OR IDENTIFYING NO.	CPN	NAME	DESCRIPTION	UMMN	ALTN PREF	DOCUMENT NO.
1.0	16	015-3622-020		SLIDE	CABINET-RIGHT			
1.0	15	015-3622-010		SLIDE	CABINET-LEFT			
10.0	14	310-0286-000		WASHER	LOCK-.216			
10.0	13	310-0050-000		WASHER	FLAT-.25			
10.0	12	343-1540-000		SCREW	.216-24 X .50			
8.0	11	MS24693-C49	342-1350-350	SCREW	.164-32 X .44 FLH			
4.0	10	310-0048-000		WASHER	FLAT-.164			
8.0	9	MS35338-137	310-0072-000	WASHER	LOCK-.164			
8.0	8	MS35649-284	313-0017-000	NUT	.164-32			
1.0	7	623-5814-002		BRACKET	SLIDE-REAR, RIGHT			
1.0	6	623-5814-001		BRACKET	SLIDE-REAR, LEFT			
1.0	5	623-5813-002		BRACKET	SLIDE-FRONT, RIGHT			
1.0	4	623-5813-001		BRACKET	SLIDE-FRONT, LEFT			
2.0	3	313-0082-000		NUT	.250-20			
2.0	2	MS35338-139	310-0288-000	WASHER	LOCK-.25			
2.0	1	623-5735-001		PIN	GUIDE			

Figure FO-1. Radio Receiver Transmitter RT-980/GRC-171, Outline and Mounting Dimensions Diagram (Sheet 2 of 2) 6-5/(6-6 blank)

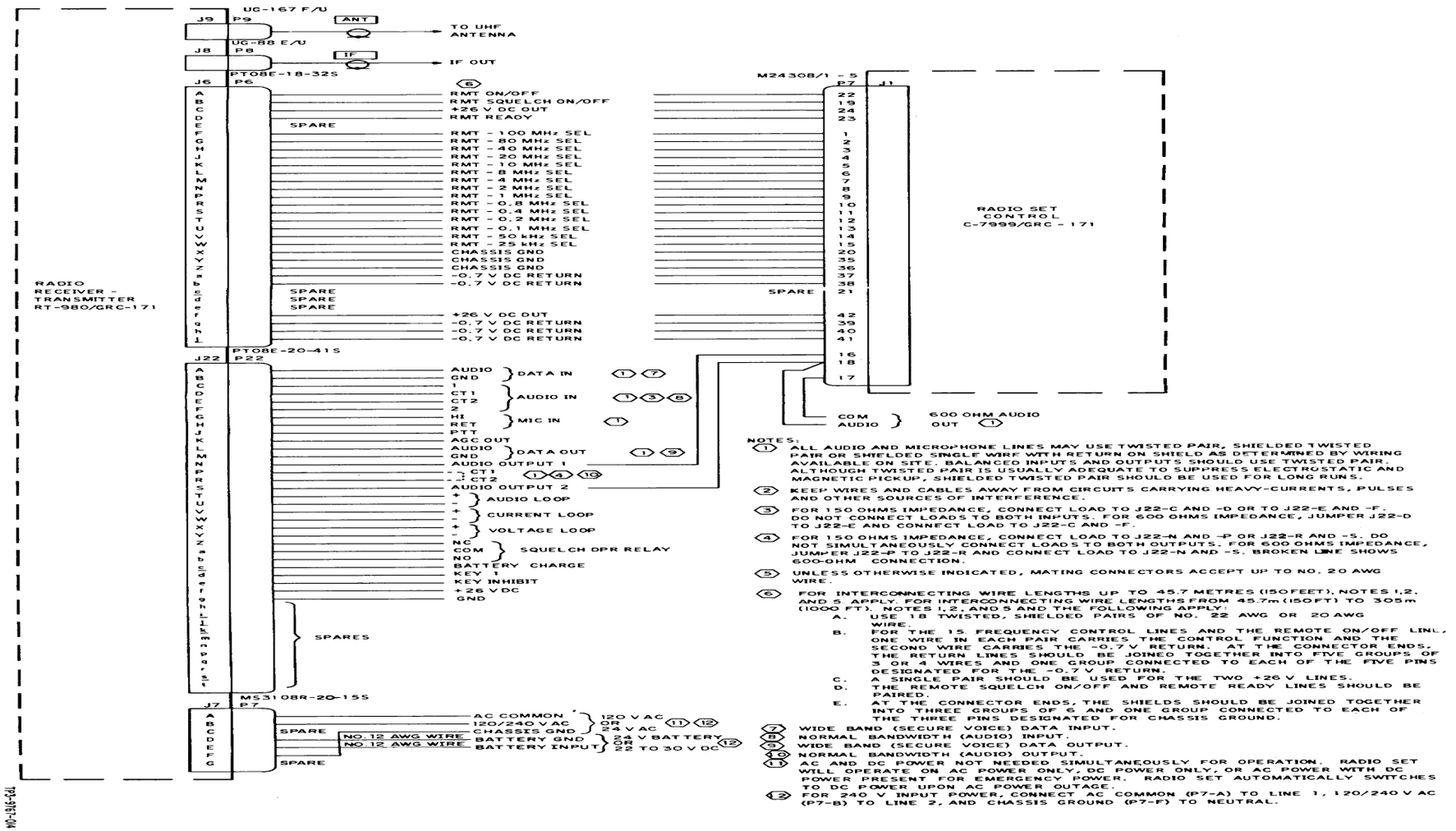

RADIO RECEIVER - TRANSMITTER RT-980/GRC-171
UG-167 F/U
J9 P9 ANT
TO UHF ANTENNA
UG-88 E/U
J8 P8 IF
IF OUT
PT08E-18-32S
J6 P6
RMT ON/OFF
RMT SQUELCH ON/OFF
+26 V DC OUT
RMT READY
SPARE
RMT - 100 MHz SEL
RMT - 80 MHz SEL
RMT - 40 MHz SEL
RMT - 20 MHz SEL
RMT - 10 MHz SEL
RMT - 8 MHz SEL
RMT - 4 MHz SEL
RMT - 2 MHz SEL
RMT - 1 MHz SEL
RMT - 0.8 MHz SEL
RMT - 0.4 MHz SEL
RMT - 0.2 MHz SEL
RMT - 0.1 MHz SEL
RMT - 50 kHz SEL
RMT - 25 kHz SEL
CHASSIS GND
CHASSIS GND
CHASSIS GND
-0.7 V DC RETURN
-0.7 V DC RETURN
SPARE
SPARE
SPARE
+26 V DC OUT
-0.7 V DC RETURN
-0.7 V DC RETURN
-0.7 V DC RETURN
PT08E-20-41S
J22 P22
AUDIO
GND
CT1
CT2
HI
RET
PTT
AGC OUT
AUDIO
GND
AUDIO OUTPUT 1
CT1
CT2
AUDIO OUTPUT 2
DATA IN
AUDIO IN
MIC IN
DATA OUT
AUDIO LOOP
CURRENT LOOP
VOLTAGE LOOP
NC
COM
NO
SQUELCH DPR RELAY
BATTERY CHARGE
KEY 1
KEY INHIBIT
+26 V DC
GND
SPARES
MS3108R-20-15S
J7 P7
AC COMMON
120/240 V AC
CHASSIS GND
BATTERY GND
BATTERY INPUT
120 V AC OR 240 V AC
24 V BATTERY OR 22 TO 30 V DC
SPARE
NO. 12 AWG WIRE
NO. 12 AWG WIRE
SPARE
M24308/1 - 5
P7 J1
SPARE
RADIO SET CONTROL C-7999/GRC - 171
COM
AUDIO
600 OHM AUDIO OUT
NOTES:
1. ALL AUDIO AND MICROPHONE LINES MAY USE TWISTED PAIR, SHIELDED TWISTED PAIR OR SHIELDED SINGLE WIRE WITH RETURN ON SHIELD AS DETERMINED BY WIRING AVAILABLE ON SITE. BALANCED INPUTS AND OUTPUTS SHOULD USE TWISTED PAIR. ALTHOUGH TWISTED PAIR IS USUALLY ADEQUATE TO SUPPRESS ELECTROSTATIC AND MAGNETIC PICKUP, SHIELDED TWISTED PAIR SHOULD BE USED FOR LONG RUNS.
2. KEEP WIRES AND CABLES AWAY FROM CIRCUITS CARRYING HEAVY-CURRENTS, PULSES AND OTHER SOURCES OF INTERFERENCE.
3. FOR 150 OHMS IMPEDANCE, CONNECT LOAD TO J22-C AND -D OR TO J22-E AND -F. DO NOT CONNECT LOADS TO BOTH INPUTS. FOR 600 OHMS IMPEDANCE, JUMPER J22-D TO J22-E AND CONNECT LOAD TO J22-C AND -F.
4. FOR 150 OHMS IMPEDANCE, CONNECT LOAD TO J22-N AND -P OR J22-R AND -S. DO NOT SIMULTANEOUSLY CONNECT LOADS TO BOTH OUTPUTS. FOR 600 OHMS IMPEDANCE, JUMPER J22-P TO J22-R AND CONNECT LOAD TO J22-N AND -S. BROKEN LINE SHOWS 600-OHM CONNECTION.
5. UNLESS OTHERWISE INDICATED, MATING CONNECTORS ACCEPT UP TO NO. 20 AWG WIRE.
6. FOR INTERCONNECTING WIRE LENGTHS UP TO 45.7 METRES (150 FEET), NOTES 1, 2, AND 5 APPLY. FOR INTERCONNECTING WIRE LENGTHS FROM 45.7m (150 FT) TO 305m (1000 FT), NOTES 1, 2, AND 5 AND THE FOLLOWING APPLY:
A. USE 18 TWISTED, SHIELDED PAIRS OF NO. 22 AWG OR 20 AWG WIRE.
B. FOR THE 15 FREQUENCY CONTROL LINES AND THE REMOTE ON/OFF LINE, ONE WIRE IN EACH PAIR CARRIES THE CONTROL FUNCTION AND THE SECOND WIRE CARRIES THE -0.7 V RETURN. AT THE CONNECTOR ENDS, THE RETURN LINES SHOULD BE JOINED TOGETHER INTO FIVE GROUPS OF 3 OR 4 WIRES AND ONE GROUP CONNECTED TO EACH OF THE FIVE PINS DESIGNATED FOR THE -0.7 V RETURN.
C. A SINGLE PAIR SHOULD BE USED FOR THE TWO +26 V LINES.
D. THE REMOTE SQUELCH ON/OFF AND REMOTE READY LINES SHOULD BE PAIRED.
E. AT THE CONNECTOR ENDS, THE SHIELDS SHOULD BE JOINED TOGETHER INTO THREE GROUPS OF 6 AND ONE GROUP CONNECTED TO EACH OF THE THREE PINS DESIGNATED FOR CHASSIS GROUND.
7. WIDE BAND (SECURE VOICE) DATA INPUT.
8. NORMAL BANDWIDTH (AUDIO) INPUT.
9. WIDE BAND (SECURE VOICE) DATA OUTPUT.
10. NORMAL BANDWIDTH (AUDIO) OUTPUT.
11. AC AND DC POWER NOT NEEDED SIMULTANEOUSLY FOR OPERATION. RADIO SET WILL OPERATE ON AC POWER ONLY, DC POWER ONLY, OR AC POWER WITH DC POWER PRESENT FOR EMERGENCY POWER. RADIO SET AUTOMATICALLY SWITCHES TO DC POWER UPON AC POWER OUTAGE.
12. FOR 240 V INPUT POWER, CONNECT AC COMMON (P7-A) TO LINE 1, 120/240 V AC (P7-B) TO LINE 2, AND CHASSIS GROUND (P7-F) TO NEUTRAL.
MIL-STD-1241

Figure FO-2. Radio Set AN/GRC-171, Installation Wiring Diagram

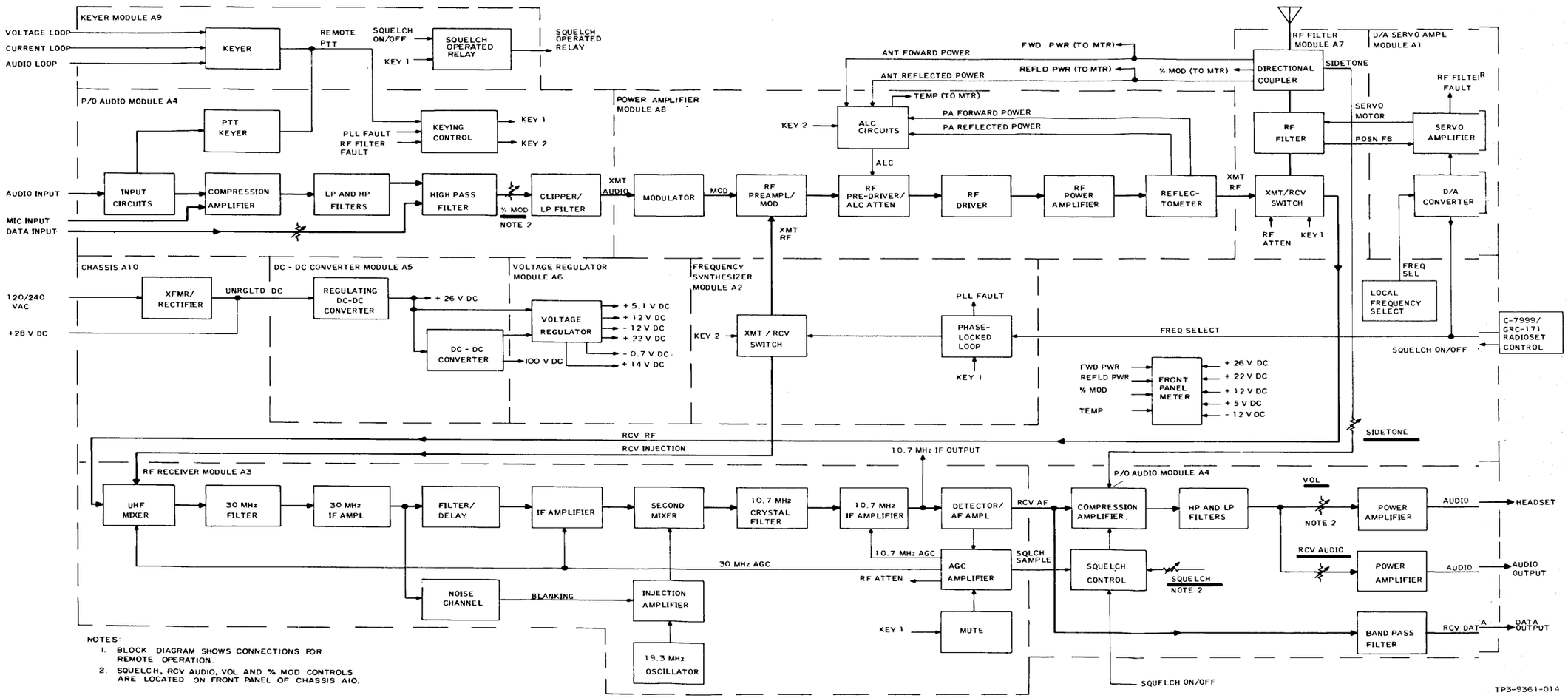


Figure FO-3. Radio Set AN/GRC-171, Block Diagram

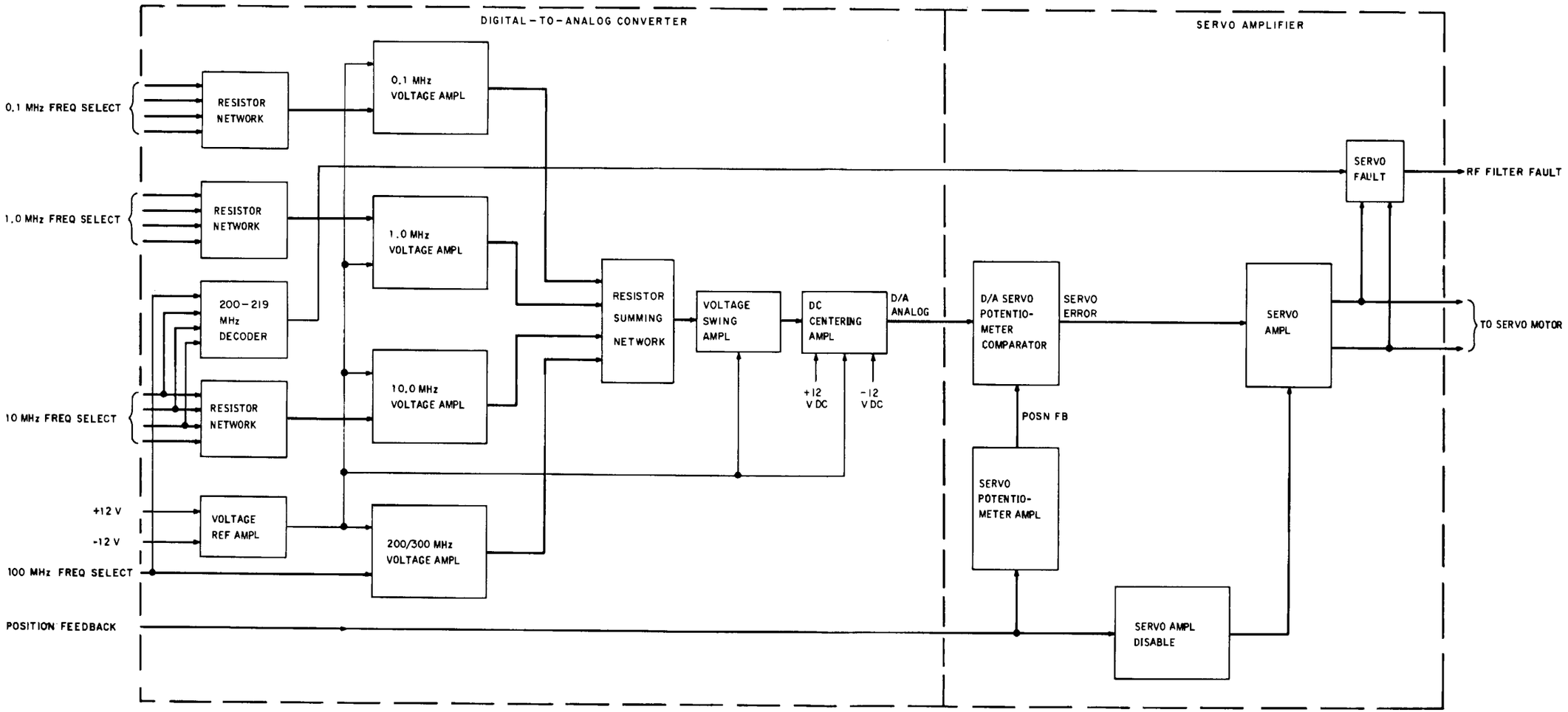


Figure FO-4. D/A Servo Amplifier Module A1, Block Diagram

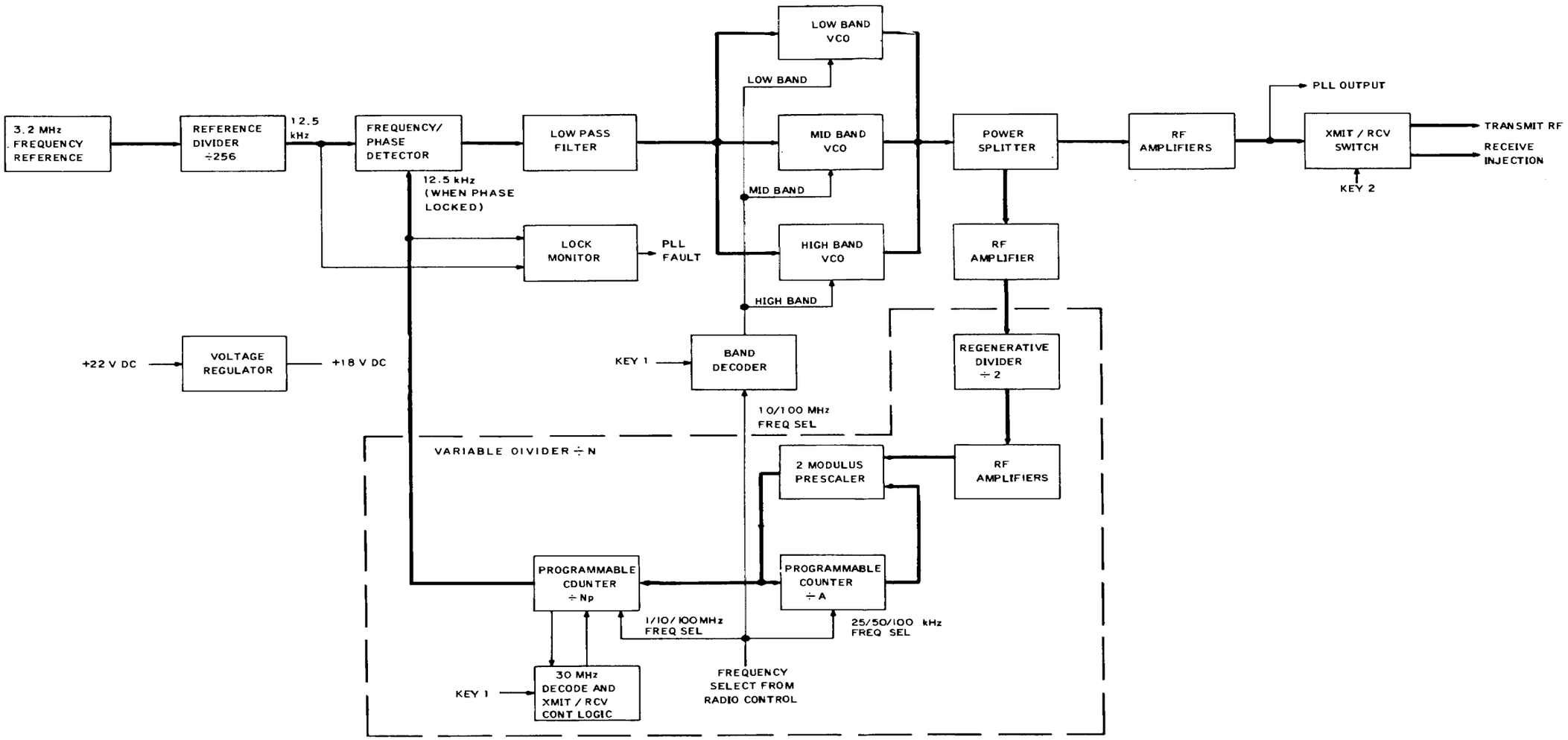


Figure FO-5. Frequency Synthesizer Module A2, Block Diagram

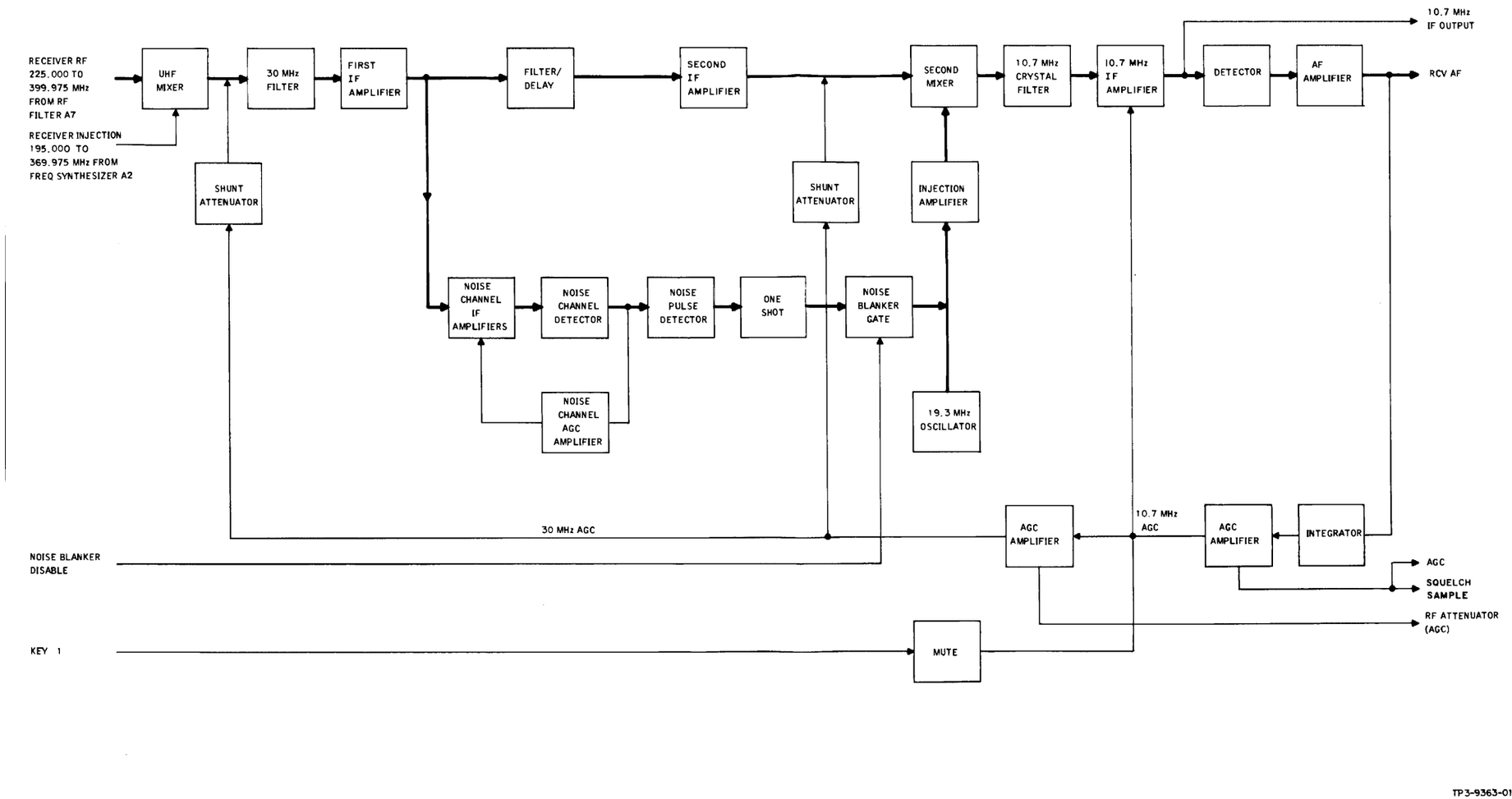


Figure FO-6. Receiver RF Module A3, Block Diagram

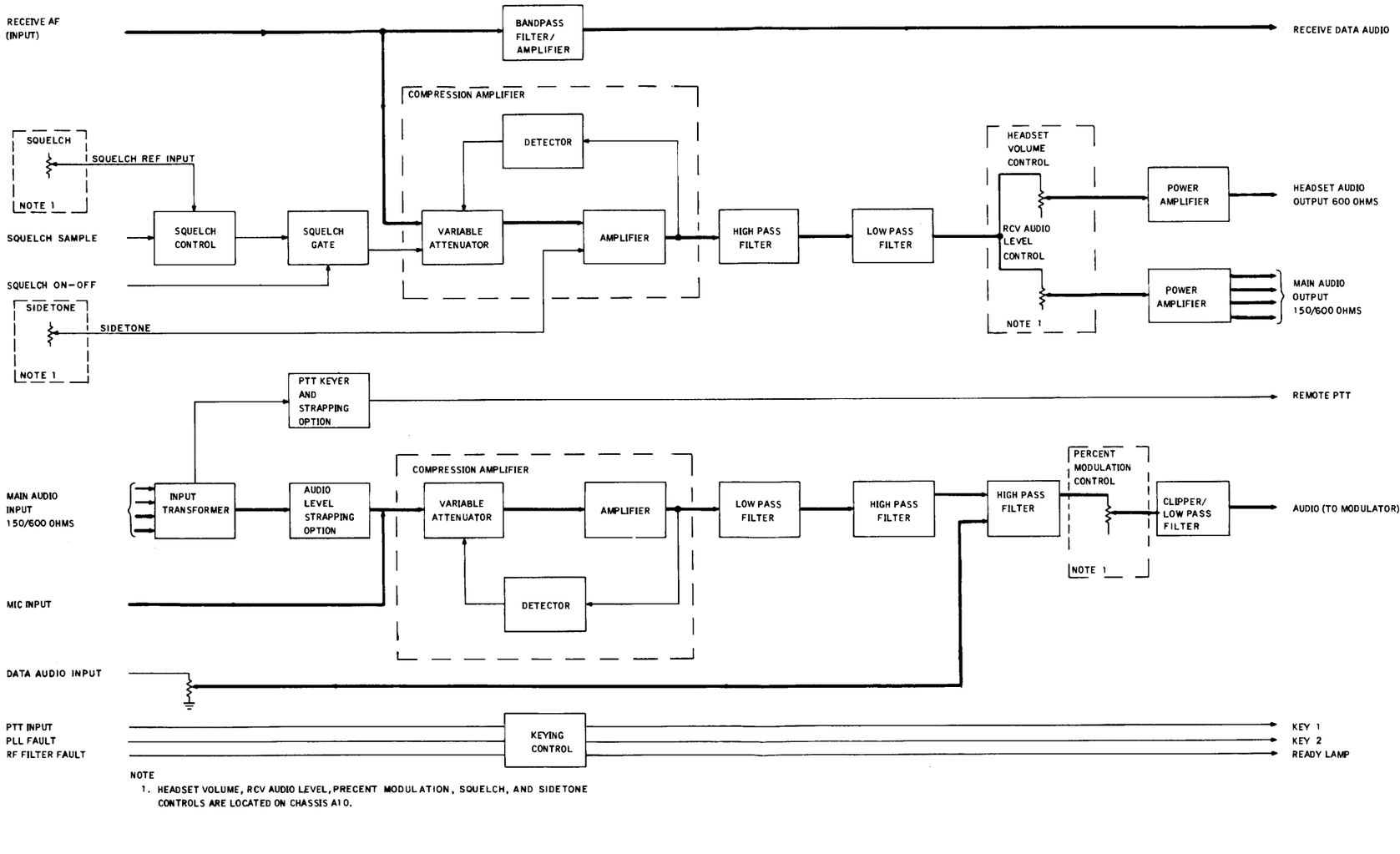


Figure FO-7. Audio Module A4, Block Diagram

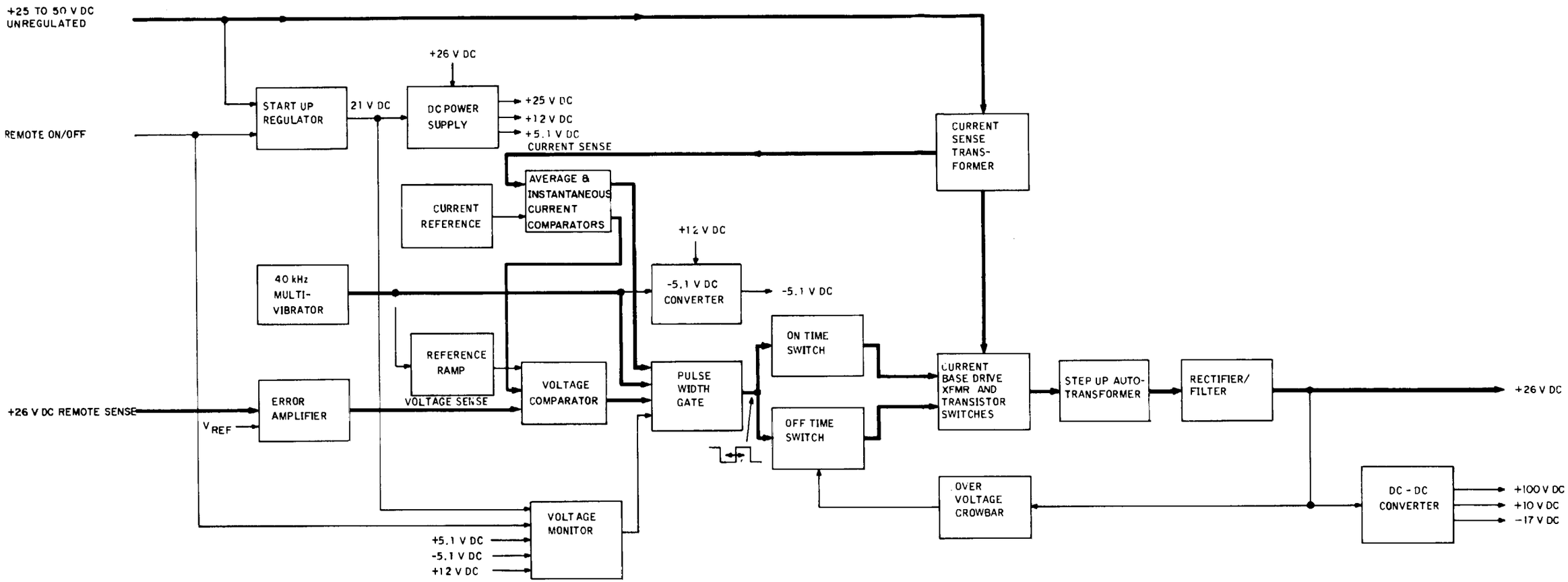


Figure FO-8. DC-DC Converter Module A5, Block Diagram

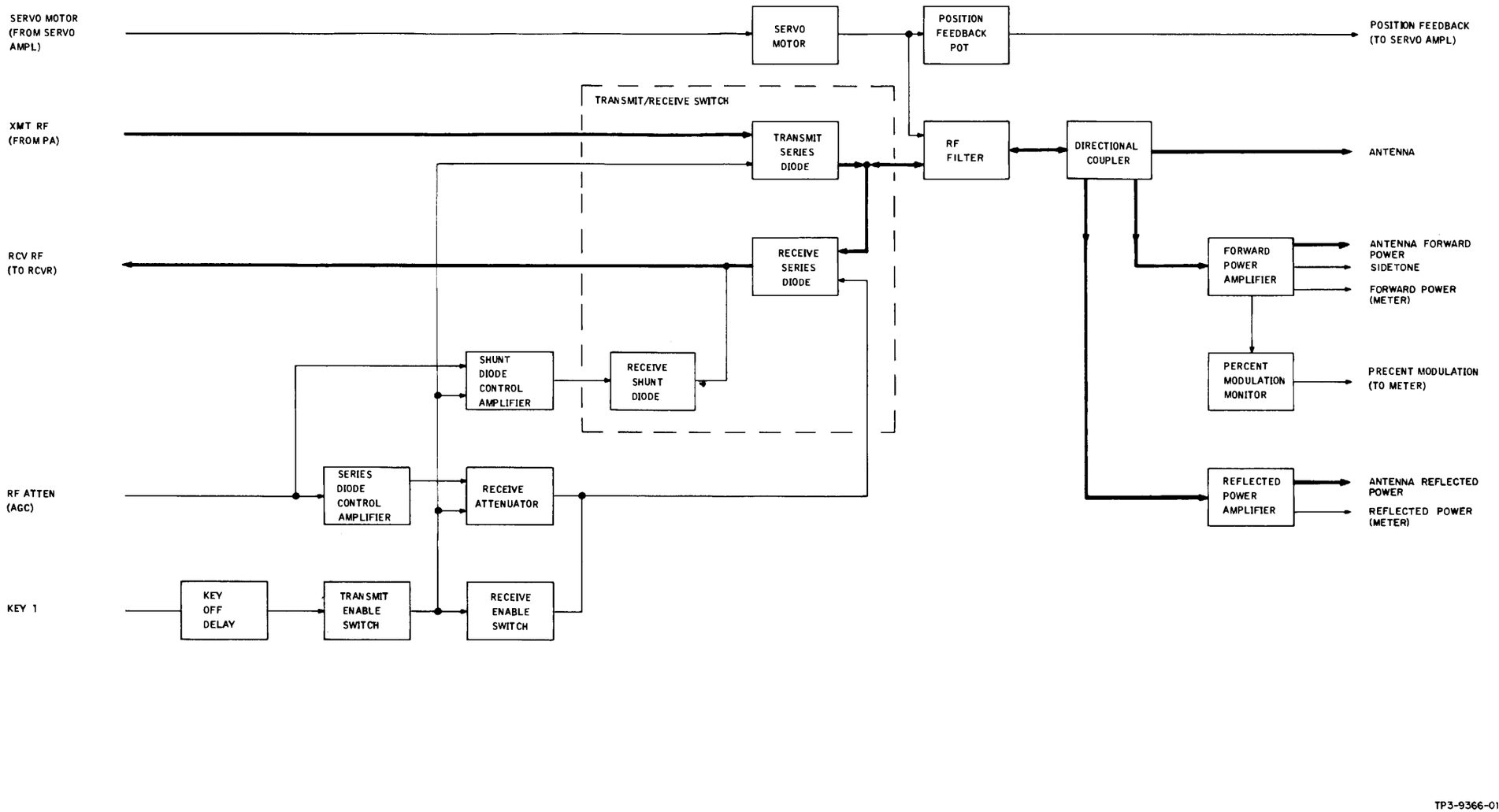


Figure FO-9. RF Filter Module A7, Block Diagram

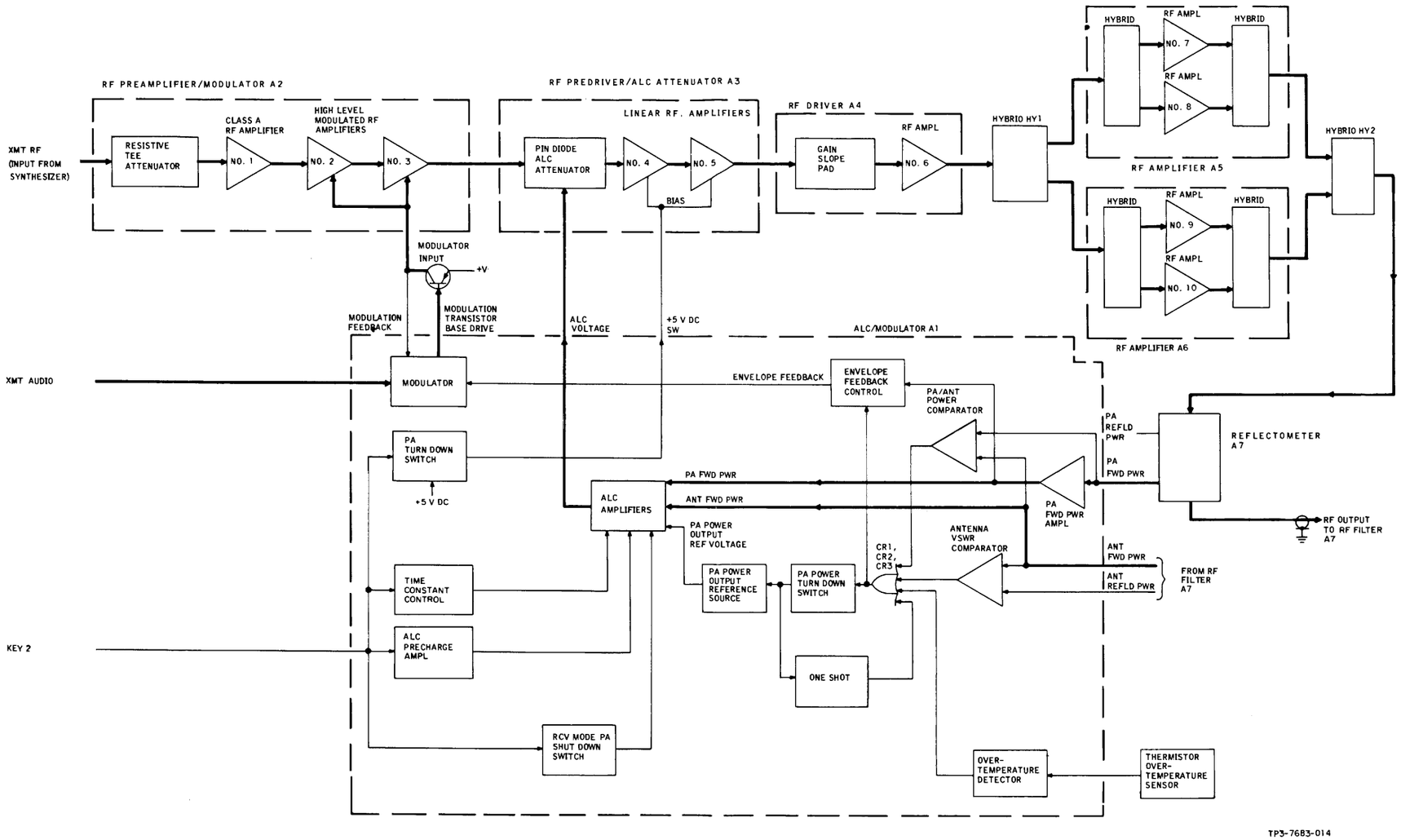


Figure FO-10. Power Amplifier Module A8, Block Diagram

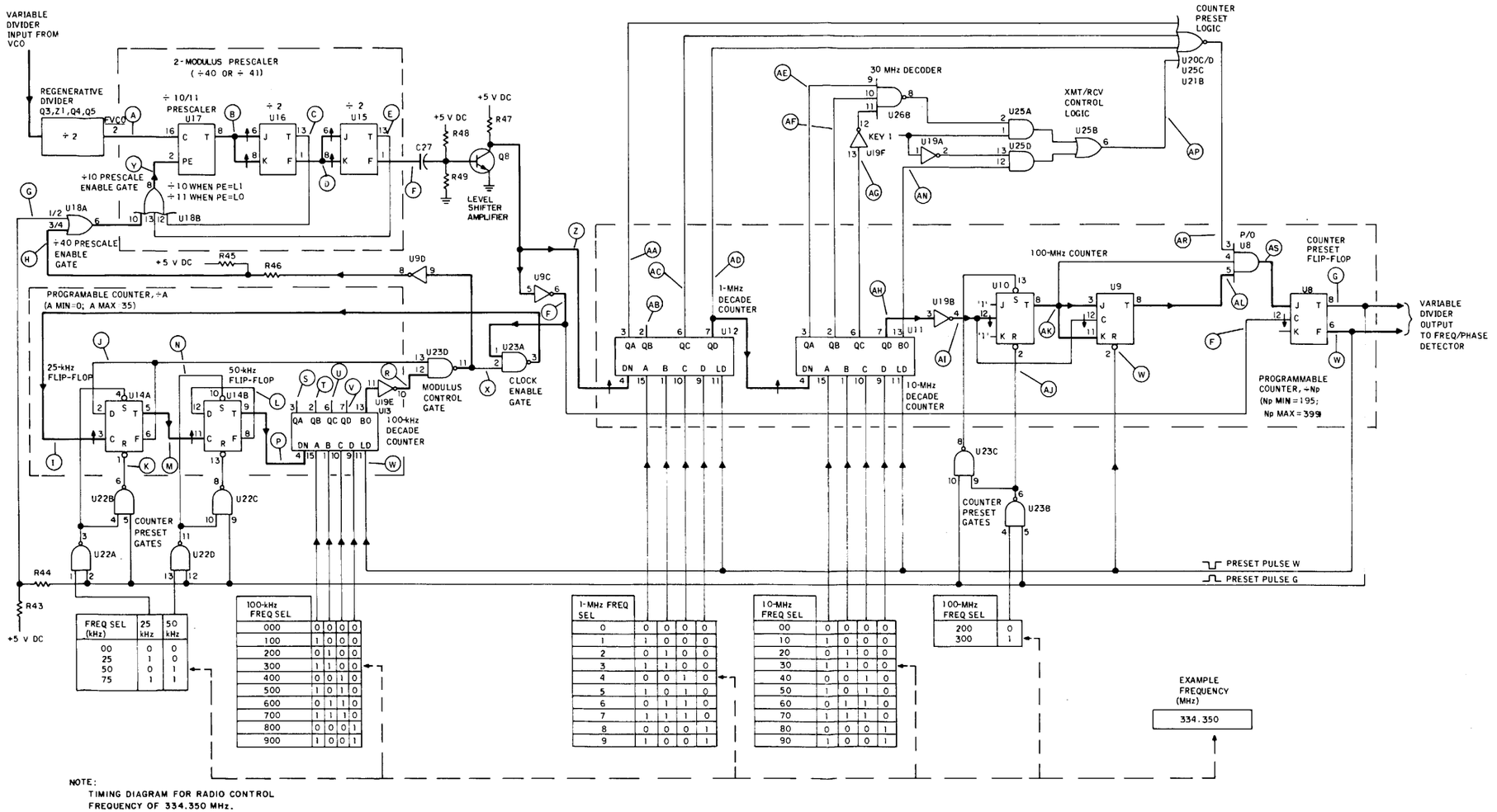


Figure FO-11. Frequency Synthesizer Variable Divider, Simplified Schematic and Timing Diagram (Sheet 1 of 3)

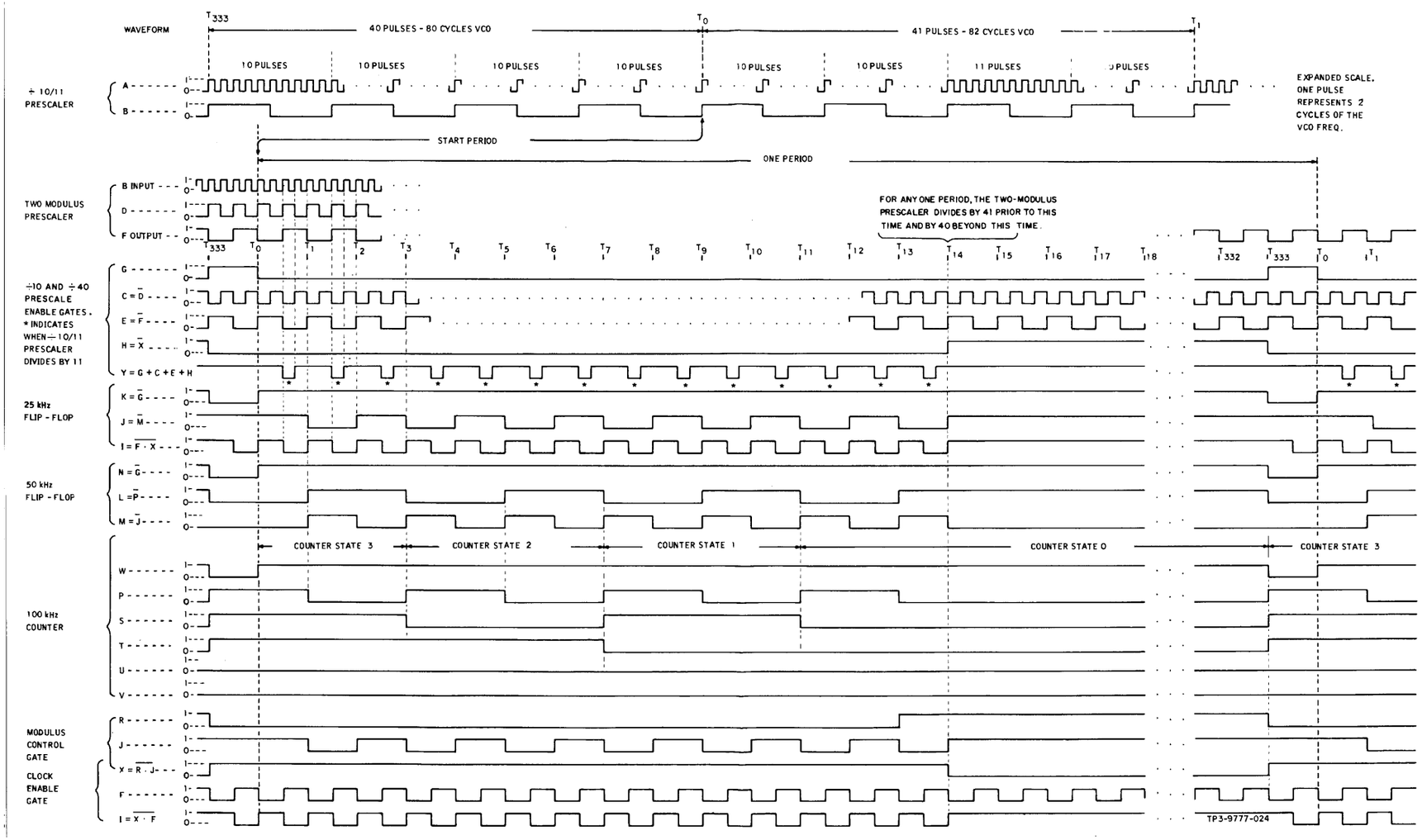

WAVEFORM
40 PULSES - 80 CYCLES VCO
41 PULSES - 82 CYCLES VCO
10 PULSES
11 PULSES
÷ 10/11 PRESCALER
EXPANDED SCALE, ONE PULSE REPRESENTS 2 CYCLES OF THE VCO FREQ.
START PERIOD
ONE PERIOD
TWO MODULUS PRESCALER
FOR ANY ONE PERIOD, THE TWO-MODULUS PRESCALER DIVIDES BY 41 PRIOR TO THIS TIME AND BY 40 BEYOND THIS TIME.
÷10 AND ÷40 PRESCALE ENABLE GATES. * INDICATES WHEN ÷ 10/11 PRESCALER DIVIDES BY 11
25 kHz FLIP - FLOP
50 kHz FLIP - FLOP
COUNTER STATE 3
COUNTER STATE 2
COUNTER STATE 1
COUNTER STATE 0
COUNTER STATE 3
100 kHz COUNTER
MODULUS CONTROL GATE
CLOCK ENABLE GATE
TP3-9777-024

Figure FO-11. Frequency Synthesizer Variable Divider, Simplified Schematic and Timing Diagram (Sheet 2 of 3)

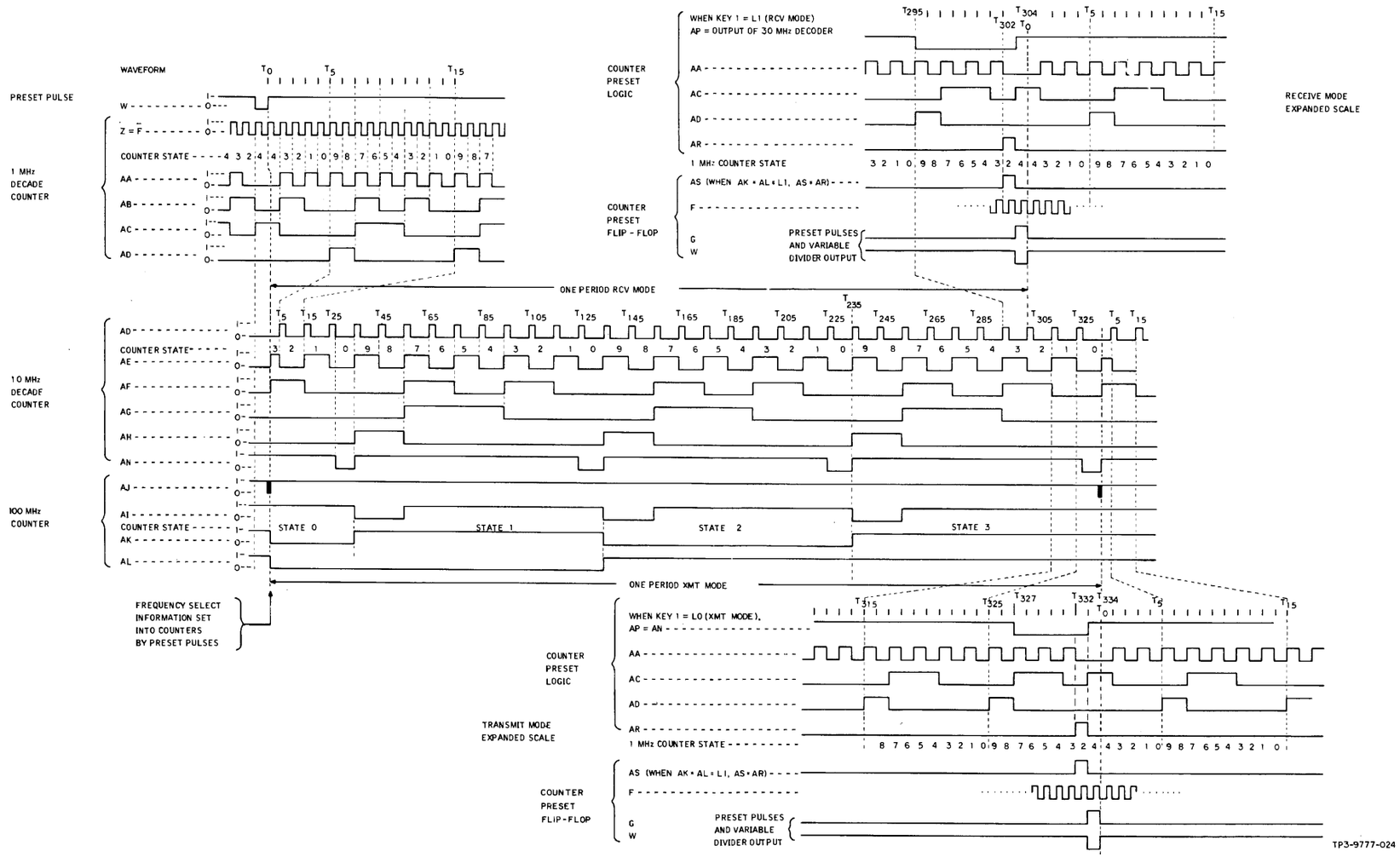
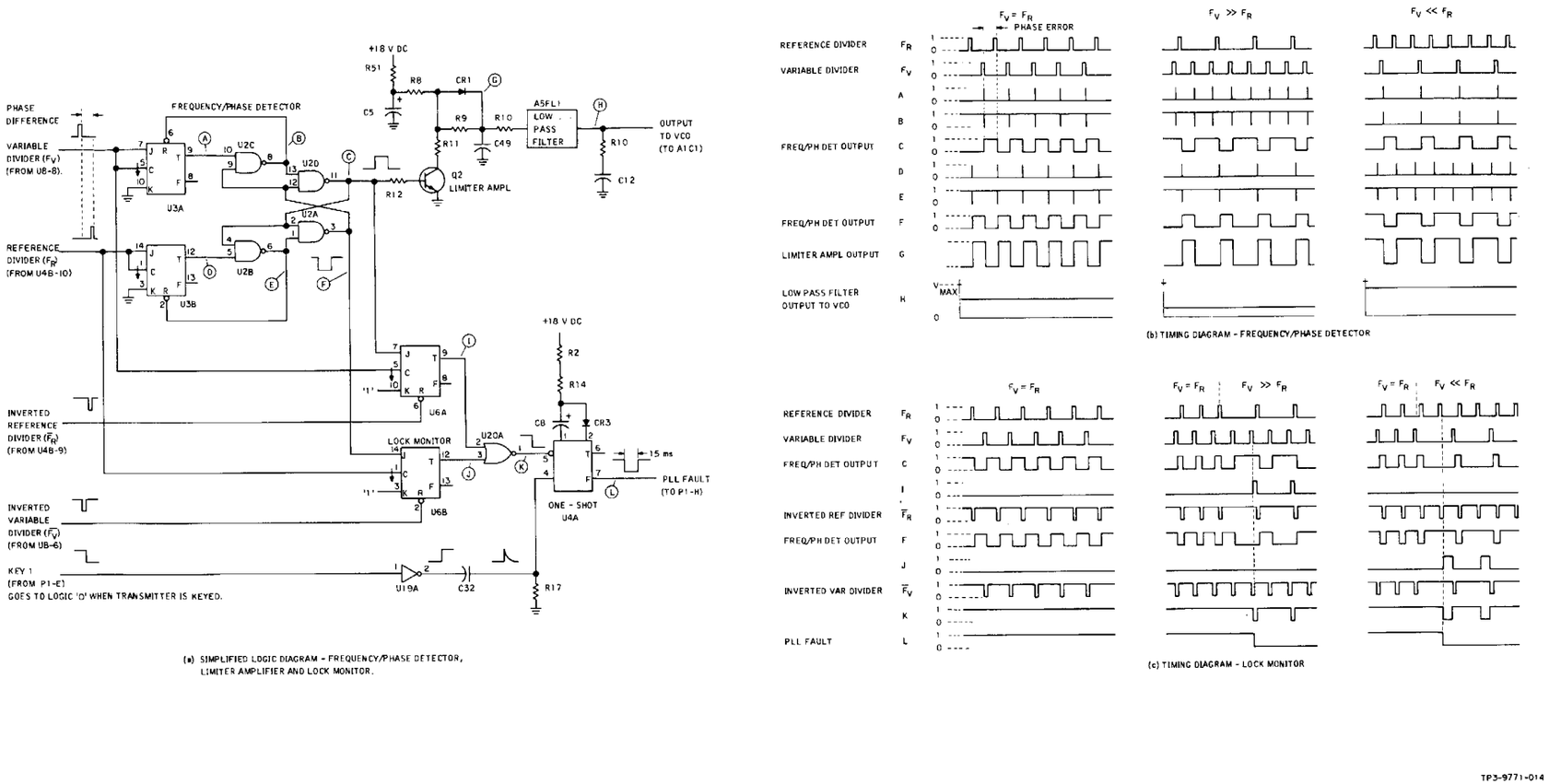


Figure FO-11. Frequency Synthesizer Variable Divider, Simplified Schematic and Timing Diagram (Sheet 3 of 3)



(a) SIMPLIFIED LOGIC DIAGRAM - FREQUENCY/PHASE DETECTOR, LIMITER AMPLIFIER AND LOCK MONITOR.

(b) TIMING DIAGRAM - FREQUENCY/PHASE DETECTOR

(c) TIMING DIAGRAM - LOCK MONITOR

Figure FO-12 . Frequency Synthesizer Frequency/Phase Detector, Limiter Amplifier, and Lock Monitor, Simplified Schematic and Timing Diagram

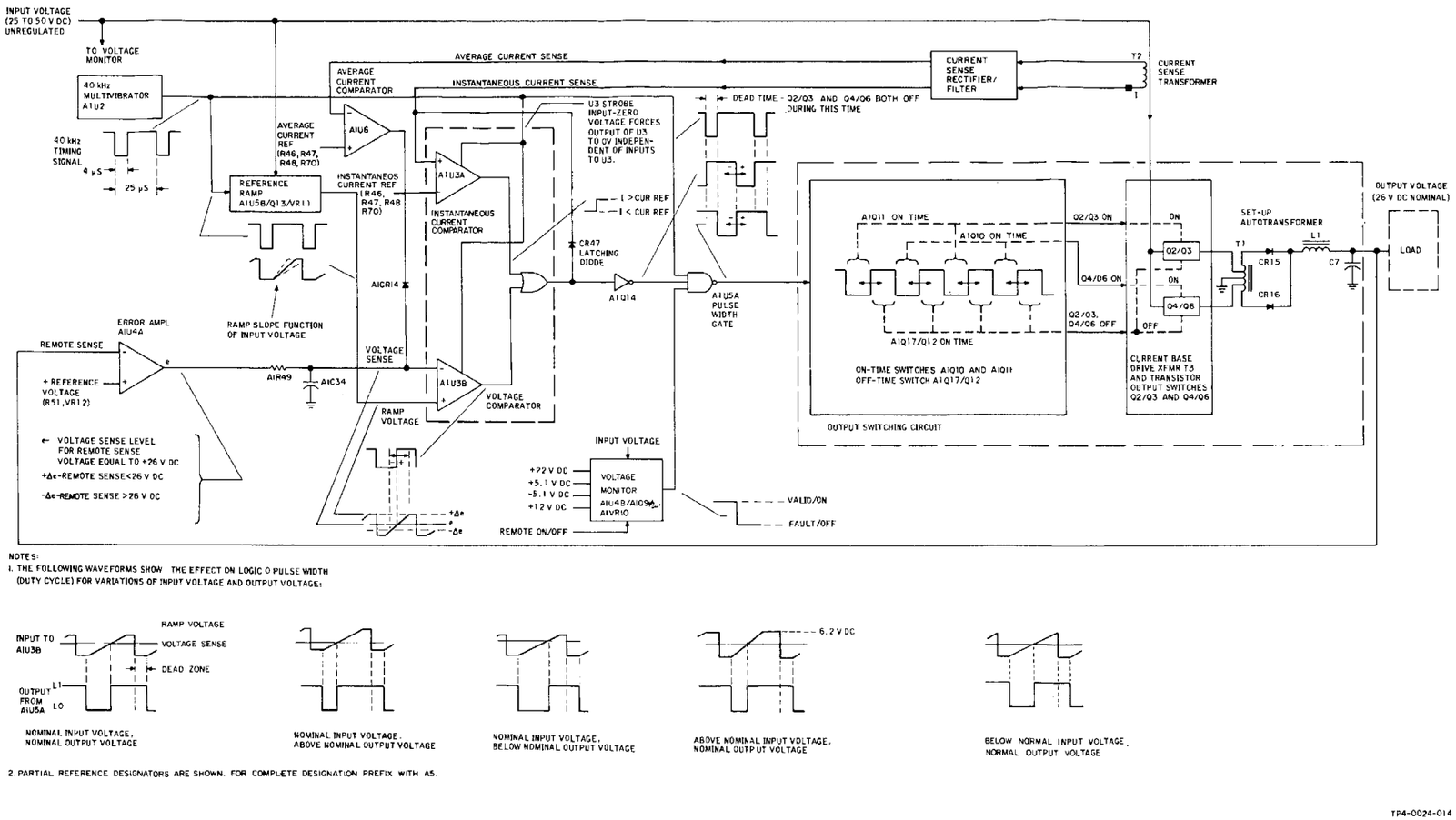


Figure FO-13. Regulating CD-DC Converter, Functional Diagram

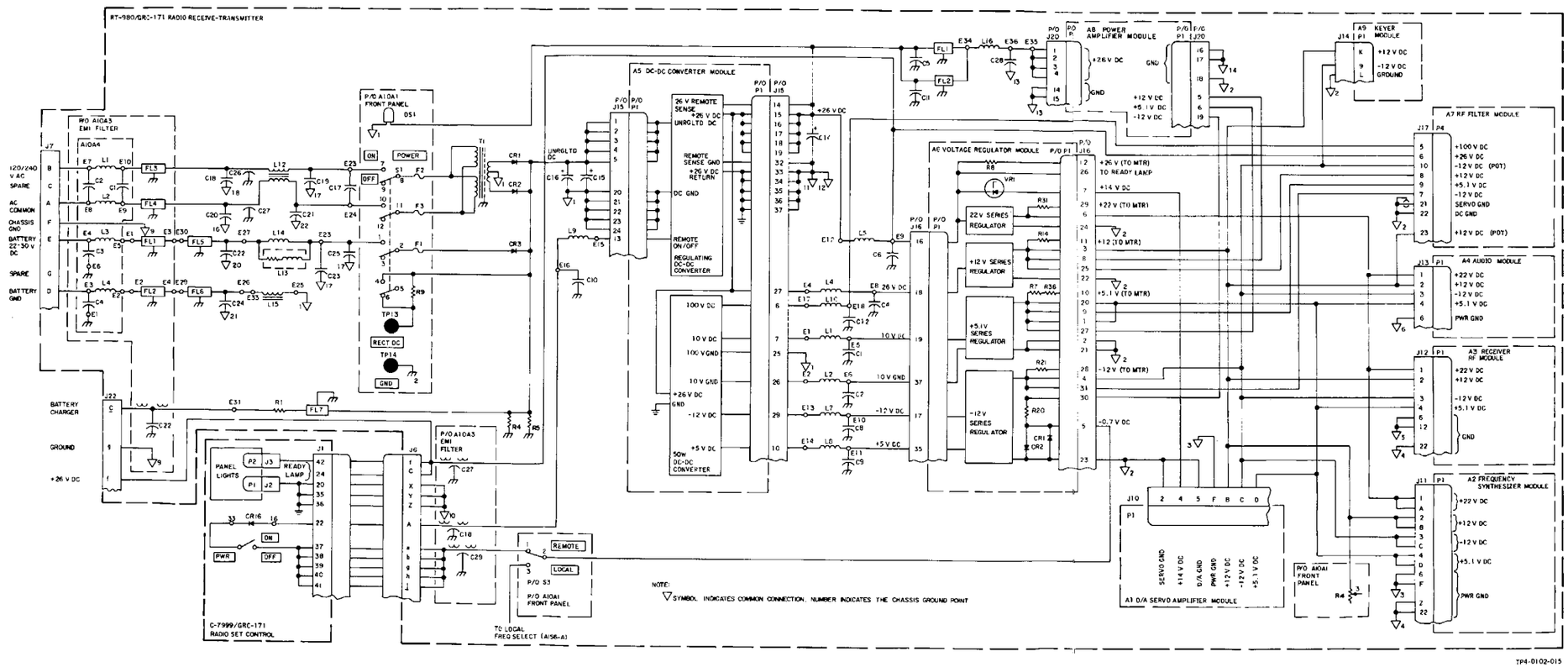


Figure FO-14. Radio Set AN/GRC-171, Power Distribution Diagram

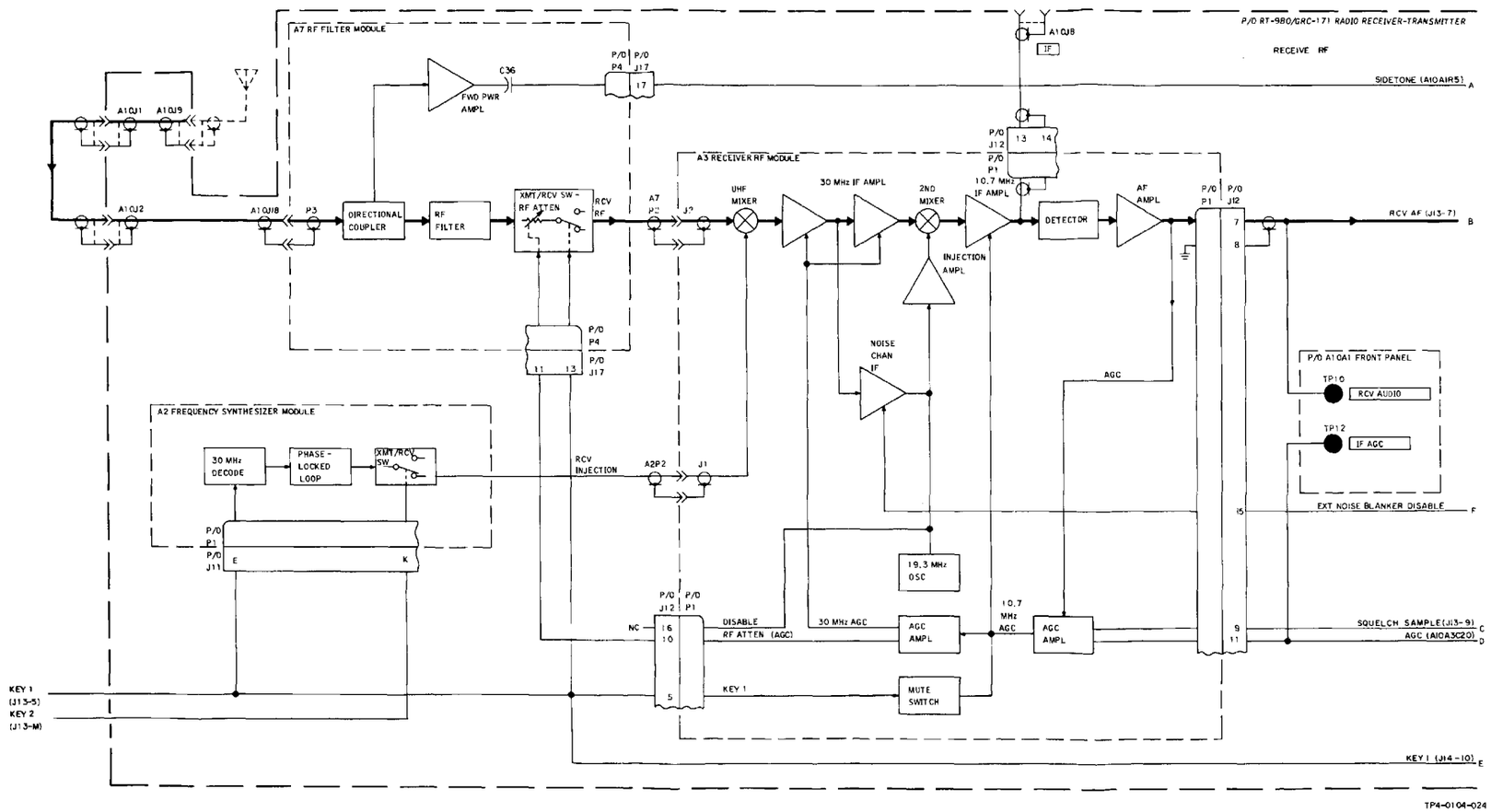


Figure FO-15. Radio Set AN/GRC-171, Receive Signal Diagram (Sheet 1 of 2)

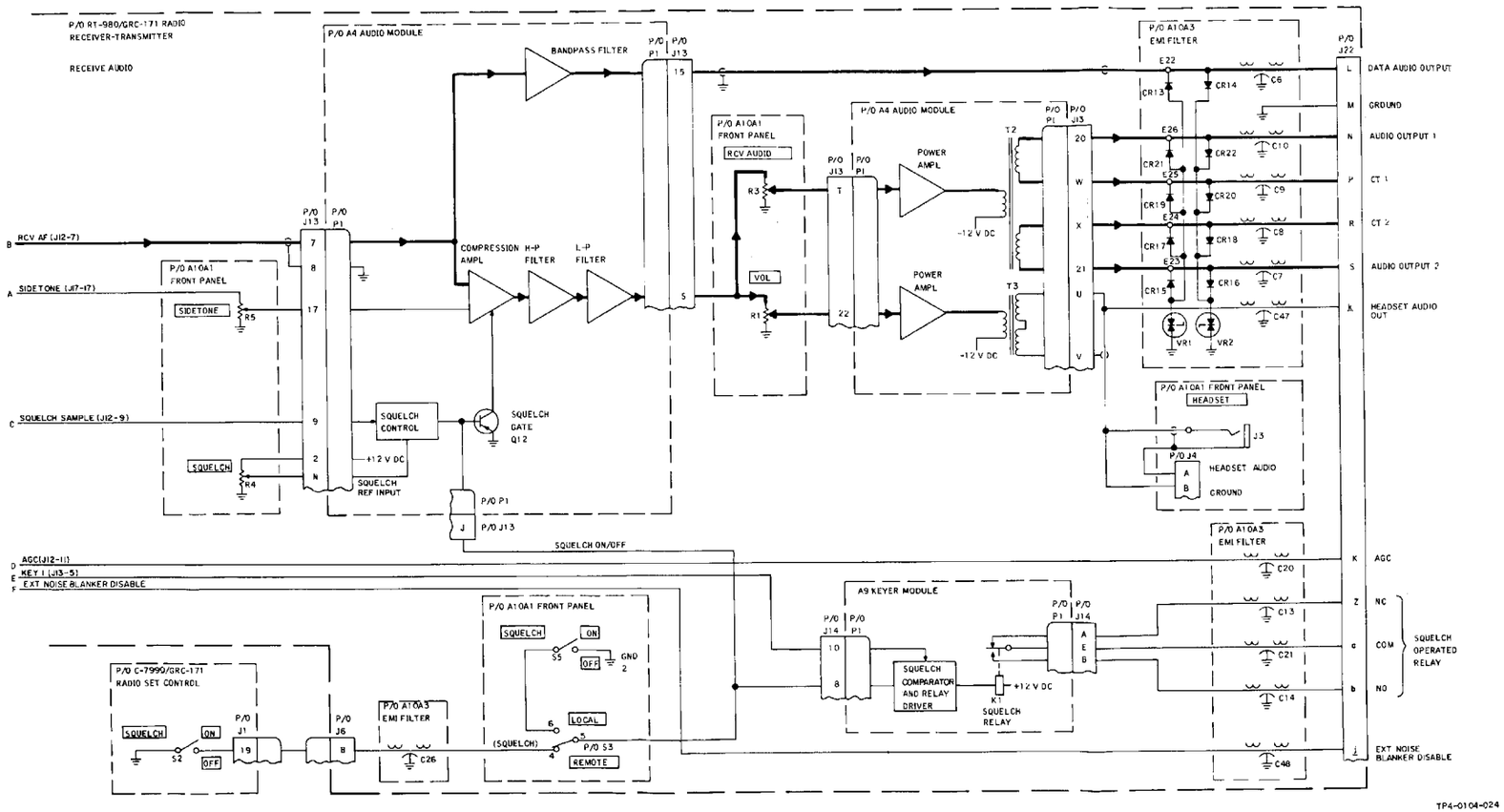


Figure FO-15. Radio Set AN/GRC-171, Receive Signal Diagram (Sheet 2 of 2)

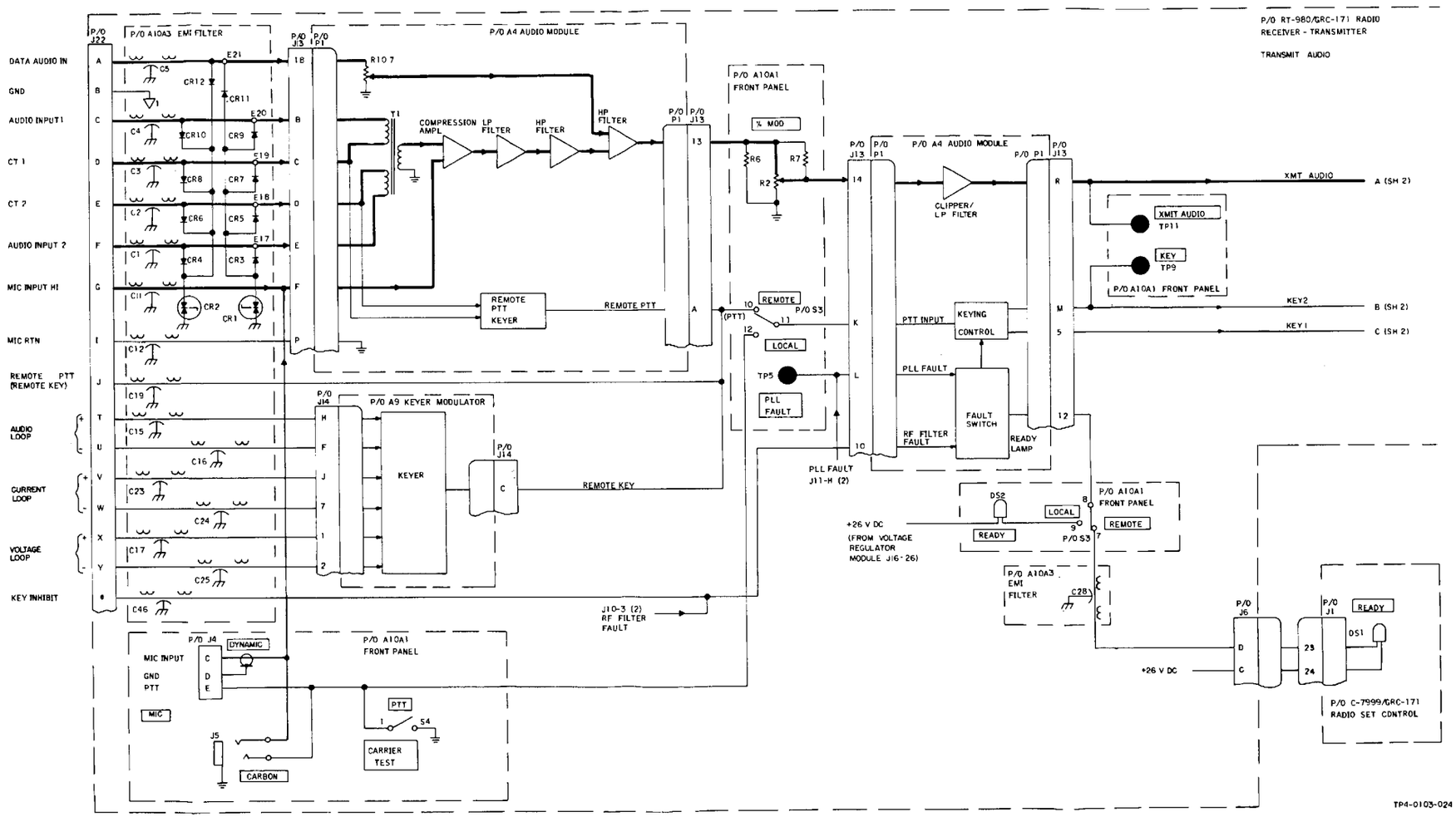


Figure FO-16. Radio Set AN/GRC-171, Transmit Signal Diagram (Sheet 1 of 2)

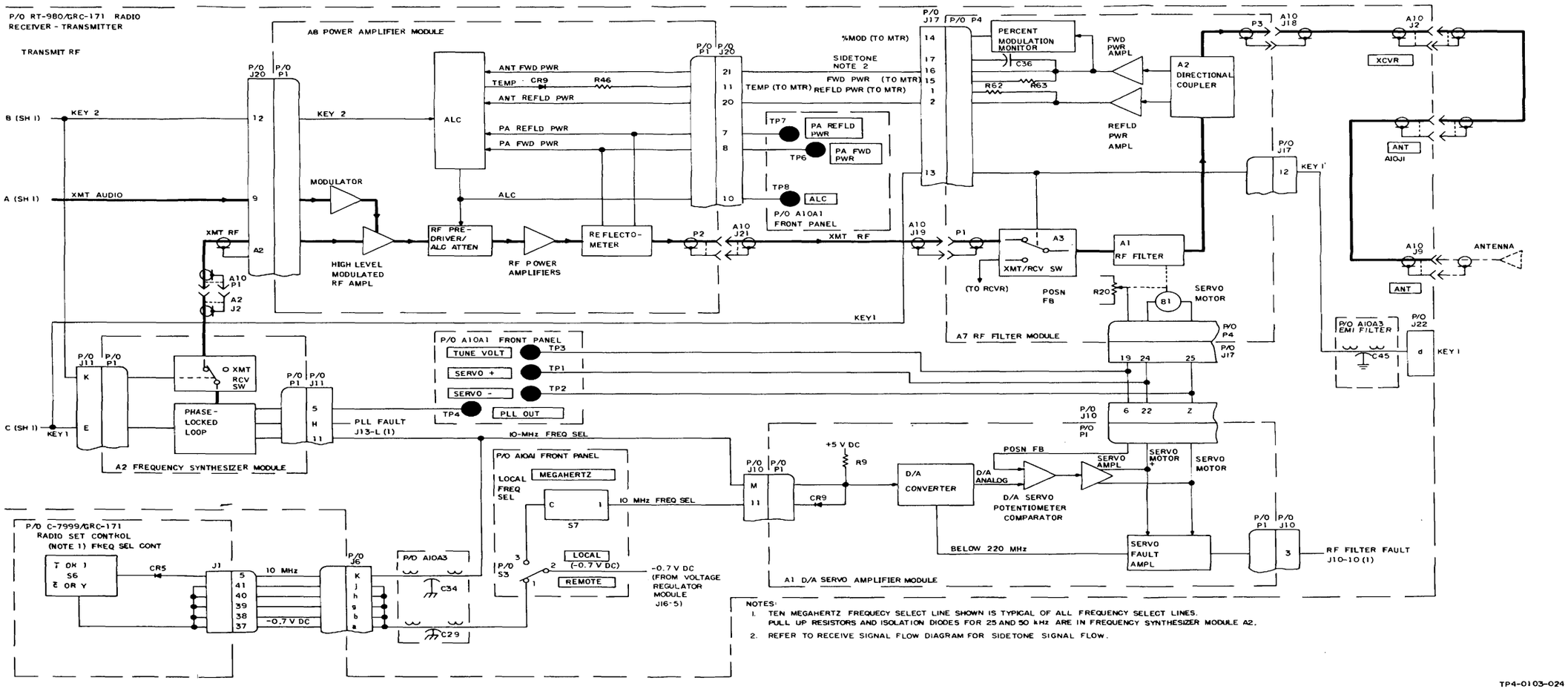


Figure FO-16. Radio Set AN/GRC-171, Transmit Signal Diagram (Sheet 2 of 2)

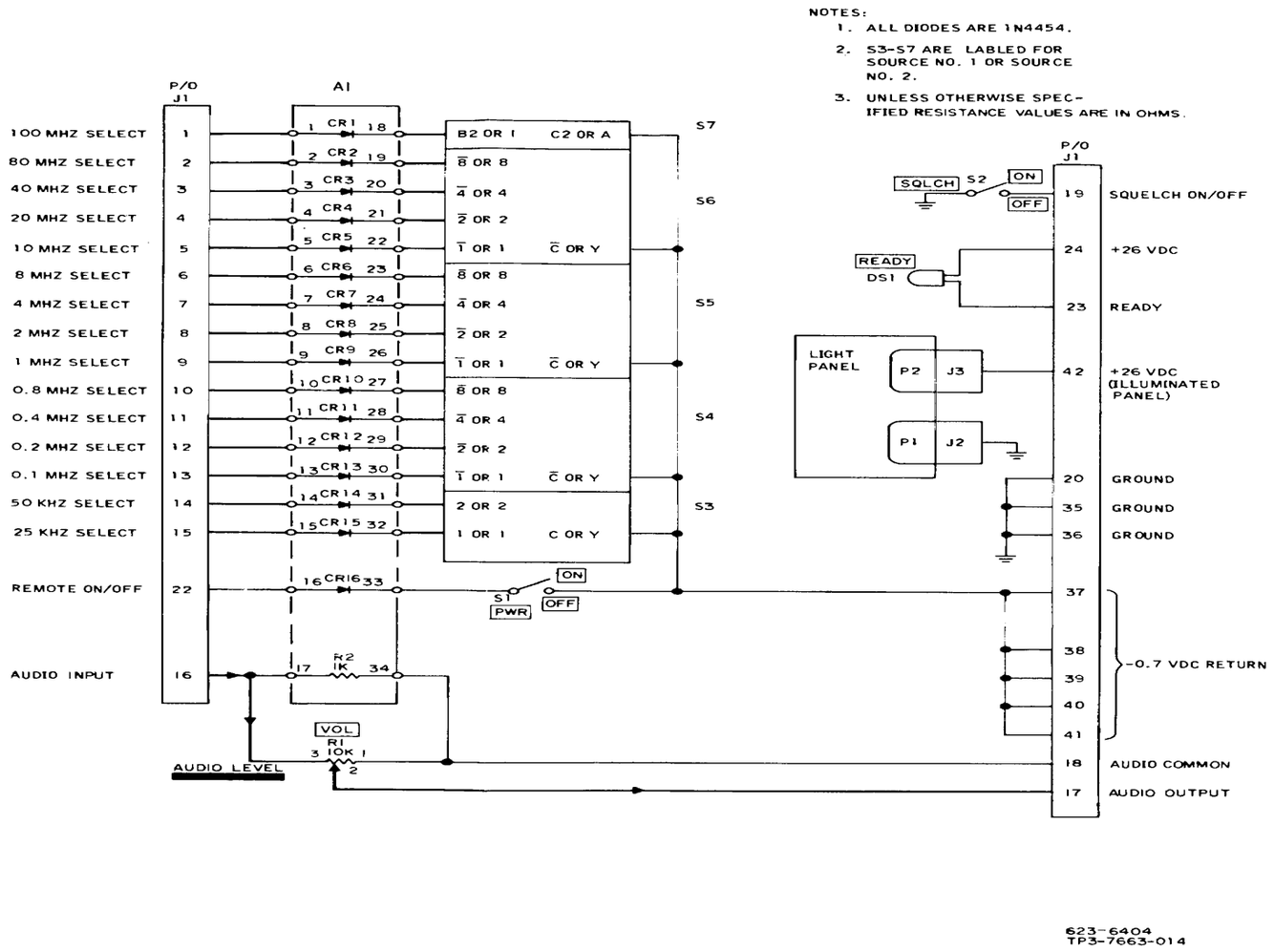


Figure FO-17. Radio Set Control C-7999/GRC-171, Schematic Diagram

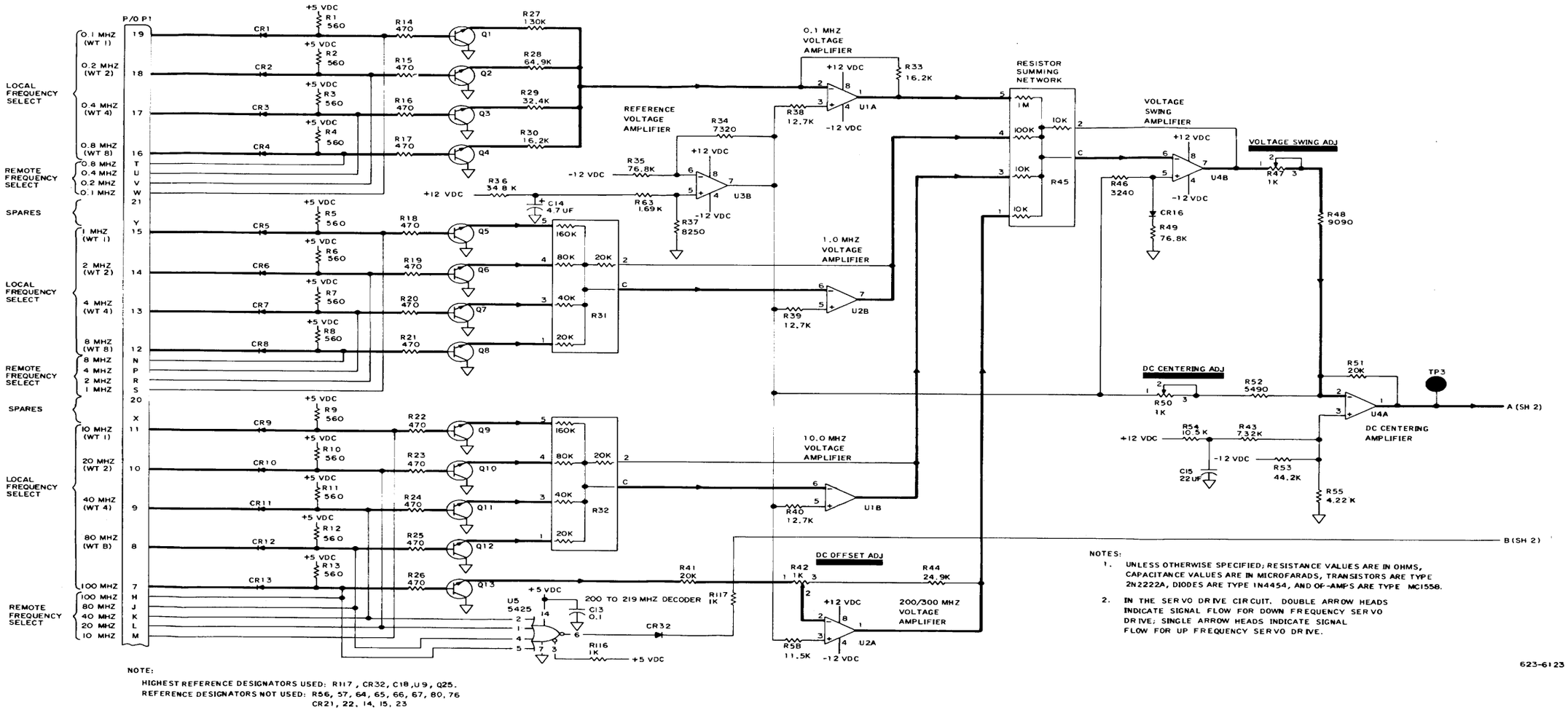


Figure FO-18. D/A Servo Amplifier Module A1, Schematic Diagram (Sheet 1 of 3)

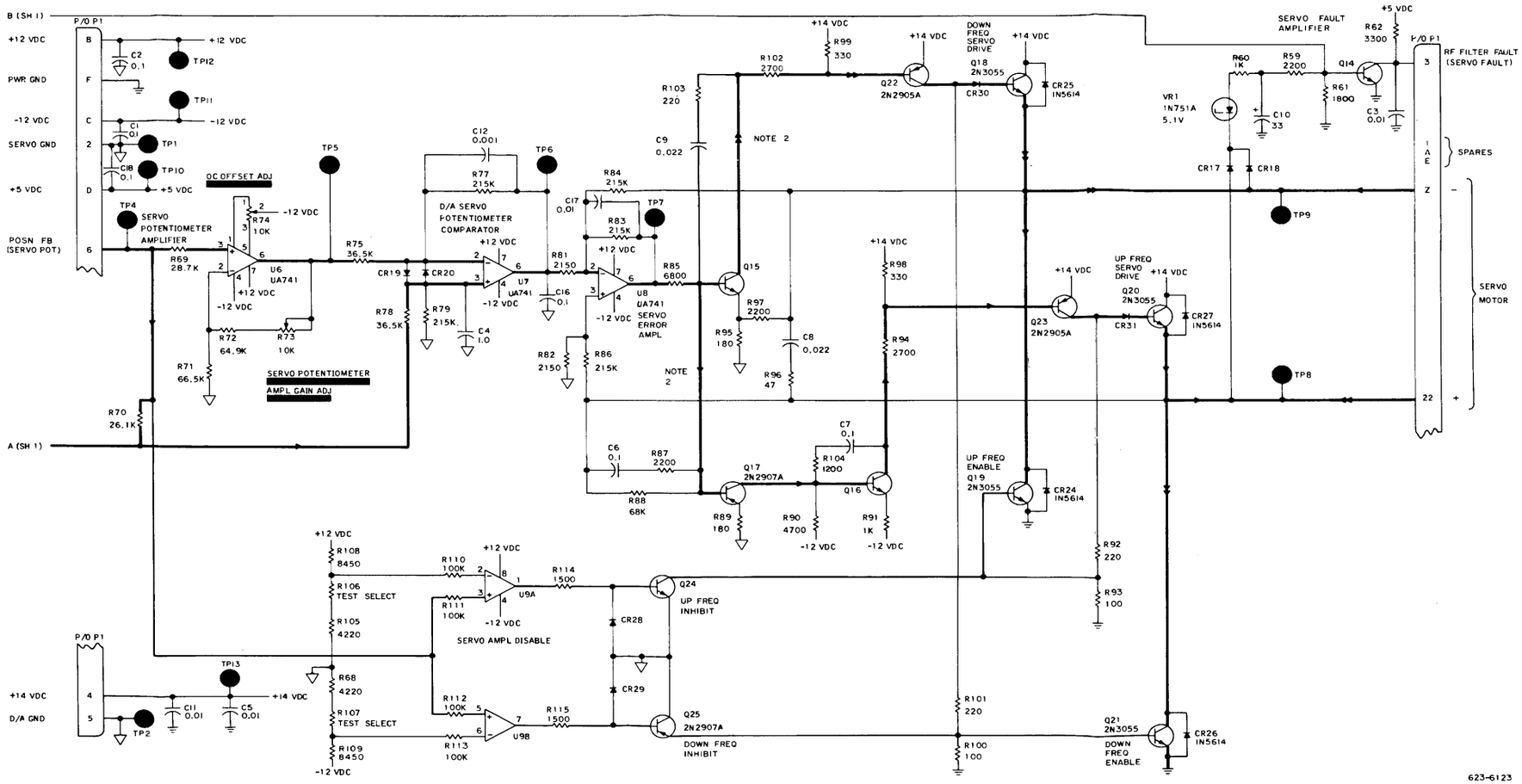


Figure FO-18. D/A Servo Amplifier Module A1, Schematic Diagram (Sheet 2 of 3)

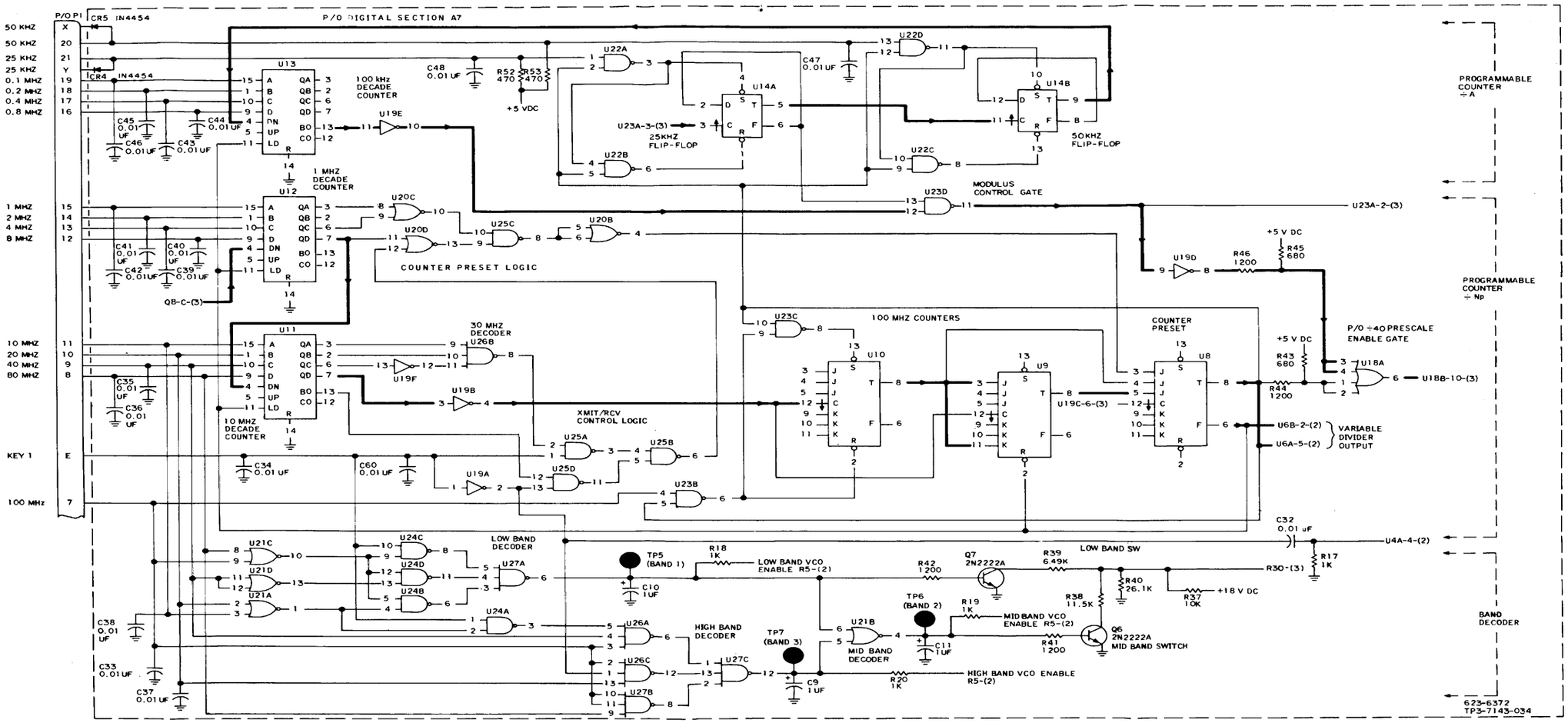


Figure FO-19. Frequency Synthesizer Module A2, Schematic Diagram (Sheet 1 of 4)

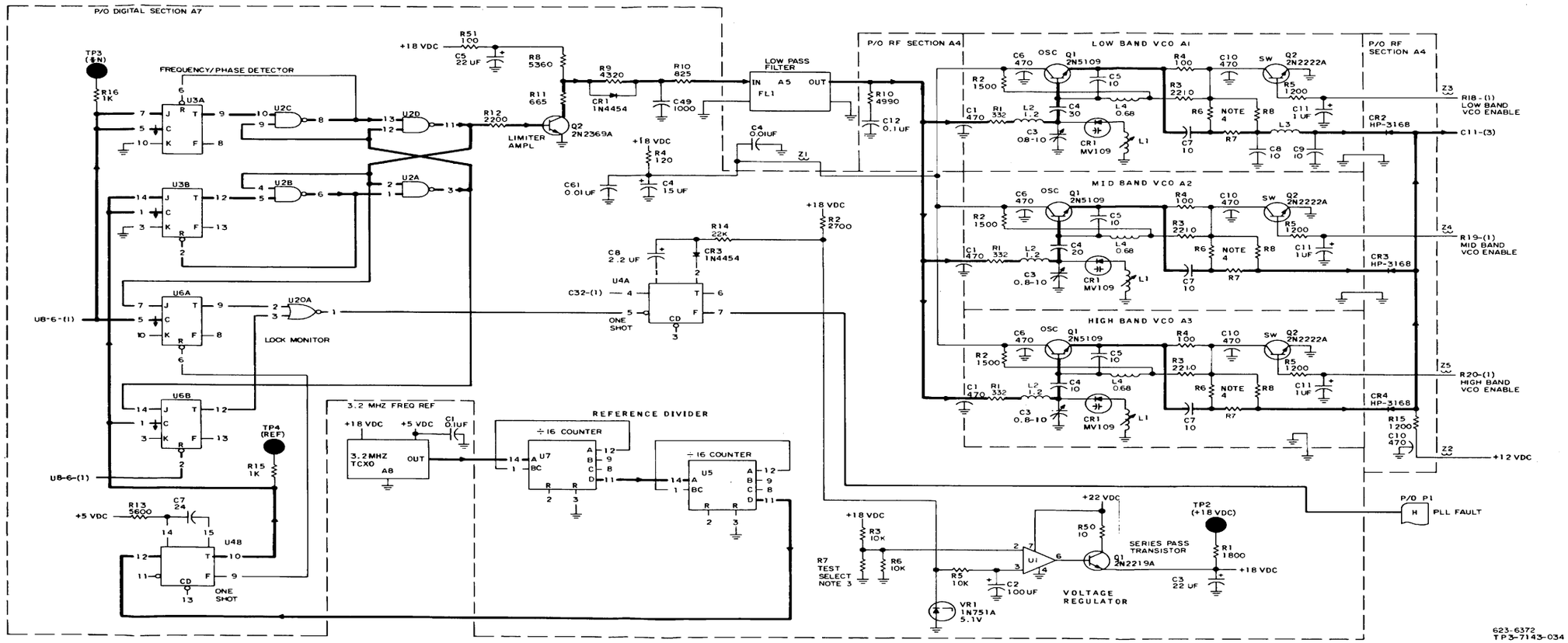


Figure FO-19. Frequency Synthesizer Module A2, Schematic Diagram (Sheet 2 of 4)

VOLTAGE AND RESISTANCE MEASUREMENTS AND TEST CONDITIONS

Typical voltage measurements were obtained under the following conditions unless noted otherwise:

Dc measurements were taken with Fluke 8000A-01 Digital Multimeter. Ground reference point was ground test point on module. Module was extended to take voltage measurements.

Resistance measurements were taken with Fluke 8000A-01 Digital Multimeter. Unless otherwise noted, measurements were taken on 20-kΩ range with module ground test point as ground reference. Module was removed from chassis to take resistance measurements.

AN/GRC-171 Test Conditions

Input power: 120 V ac, 60 Hz

Receive mode

Front panel control settings

REMOTE/LOCAL switch	LOCAL
SQUELCH switch	OFF
PTT/CARRIER TEST switch	PTT
FREQUENCY switches	300.000 MHz

Voltages and resistances are not absolute and may vary between radio sets because of normal differences in component characteristics.

A1 TRANSISTOR VOLTAGE AND RESISTANCE MEASUREMENTS

	VOLTAGE (V dc)			RESISTANCE (ohms)		
LEAD	E	B	C	E	B	C
Q1	+3.56	+0.1	0	*620 kΩ	5600	0
Q2	+3.56	+0.1	0	*560 kΩ	5600	0
Q3	+3.56	+0.1	0	*520 kΩ	5600	0
Q4	+3.56	+0.1	0	*510 kΩ	5600	0
Q5	+3.56	+0.1	0	*390 kΩ	5600	0
Q6	+3.56	+0.1	0	*310 kΩ	5600	0
Q7	+3.56	+0.1	0	*270 kΩ	5600	0
Q8	+3.56	+0.1	0	*250 kΩ	5600	0
Q9	+3.56	+0.1	0	*300 kΩ	5600	0
Q10	+3.56	+0.1	0	*220 kΩ	5600	0
Q11	+3.56	+0.1	0	*180 kΩ	5600	0
Q12	+3.56	+0.1	0	*160 kΩ	5600	0
Q13	+3.56	+0.7	0	*170 kΩ	5600	0
Q14	0	0	+5.1	0	**2200	**18.5
Q15	0 to +0.7	-0.7 to +1.3	+6 to +14	180	6200	> 2 MΩ
Q16	-10 to -12	-9 to -12	+6 to +14	11 kΩ	11 kΩ	> 2 MΩ
Q17	-0.3 to 0	-0.7 to -1.3	-9 to -12	180	6200	11 kΩ
Q18	0 to +6.5	0.2 to +7.2	+14	2400	6600	> 2 MΩ
Q19	0	0 to +0.7	0 to +6.5	**0	**100	**13 kΩ
Q20	0 to +6.5	0.2 to +7.2	+14	11 kΩ	15 kΩ	> 2 MΩ
Q21	0	0 to +0.7	0 to +6.5	**0	**100	**660 kΩ
Q22	+14	+13 to +14	0 to +5	** > 2 MΩ	> 2 MΩ	**320
Q23	+14	+13 to +14	0 to +5	** > 2 MΩ	> 2 MΩ	**320
Q24	0	-0.7	0	0	5900	6000
Q25	0	+0.7	0	6100	5100	0

*Measured on 2000-kΩ range.
**Measured with respect to power ground (P1-F).

A1 INTEGRATED CIRCUIT VOLTAGE AND RESISTANCE MEASUREMENTS

PIN	VOLTAGE (V dc)								
	U1	U2	U3	U4	U5	U6	U7	U8	U9
1	+3.56	+8.05	NC	-1.14	+0.1	-12	-12	-12	-10
2	+3.56	+3.56	NC	+1.27	+0.1	-0.57	-1	±0.01	4.06
3	+3.56	+3.56	NC	+1.27	-5.1	-0.57	-1	±0.01	-0.57
4	-12	-12	-12	-12	+0.1	-12	-12	-12	-12
5	+3.56	+3.56	+2.21	+3.4	+2.6	-12	-12	-12	-0.57
6	+3.56	+3.56	+2.21	+3.4	+0.06	-1.14	±0.02	±1.3	-4.06
7	+3.56	+3.56	+3.56	-1.29	0	+12	+12	+12	+11
8	+12	+12	+12	+12	0	0	0	0	+12
9-13	NC	NC	NC	NC	+1.7	NC	NC	NC	NC
14	NC	NC	NC	NC	+5.1	NC	NC	NC	NC
	RESISTANCE (ohms)								
1	12 kΩ	12 kΩ	NC	12 kΩ	5000	11 kΩ	11 kΩ	11 kΩ	7000
2	*490 kΩ	*150 kΩ	NC	12 kΩ	5000	*58 kΩ	*120 kΩ	13 kΩ	*120 kΩ
3	*100 kΩ	*100 kΩ	NC	4000	6000	*123 kΩ	*100 kΩ	2000	*220 kΩ
4	10 kΩ	10 kΩ	10 kΩ	10 kΩ	5000	10 kΩ	10 kΩ	10 kΩ	10 kΩ
5	*100 kΩ	*100 kΩ	12 kΩ	12 kΩ	5000	10 kΩ	11 kΩ	11 kΩ	*220 kΩ
6	*140 kΩ	*200 kΩ	12 kΩ	12 kΩ	14 kΩ	12 kΩ	11 kΩ	9000	*151 kΩ
7	12 kΩ	12 kΩ	12 kΩ	12 kΩ	0	12 kΩ	12 kΩ	12 kΩ	6000
8	12 kΩ	12 kΩ	12 kΩ	12 kΩ	0	> 2 MΩ	> 2 MΩ	> 2 MΩ	12 kΩ
9-13	NC	NC	NC	NC	5000	NC	NC	NC	NC
14	NC	NC	NC	NC	5000	NC	NC	NC	NC

*Measured on 2000-kΩ range.
NC - No connection.

A1 TEST POINT VOLTAGE AND RESISTANCE MEASUREMENTS

TEST POINT	V DC	OHMS
1	0 (gnd)	0
2	0 (gnd)	0
3	-1.14	12 kΩ
4	-0.57	*120 kΩ
5	-1.14	12 kΩ
6	±0.02	11 kΩ
7	±1	8900
8	0 to +6.5	11 kΩ
9	0 to +6.5	2300
10	+5.1	5000
11	-12	10 kΩ
12	+12	12 kΩ
13	+14	> 2 MΩ

*Measured on 2000-kΩ range.

PIN LOCATION DIAGRAMS

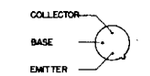
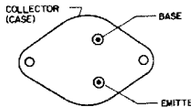
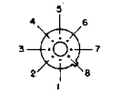
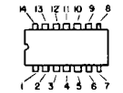
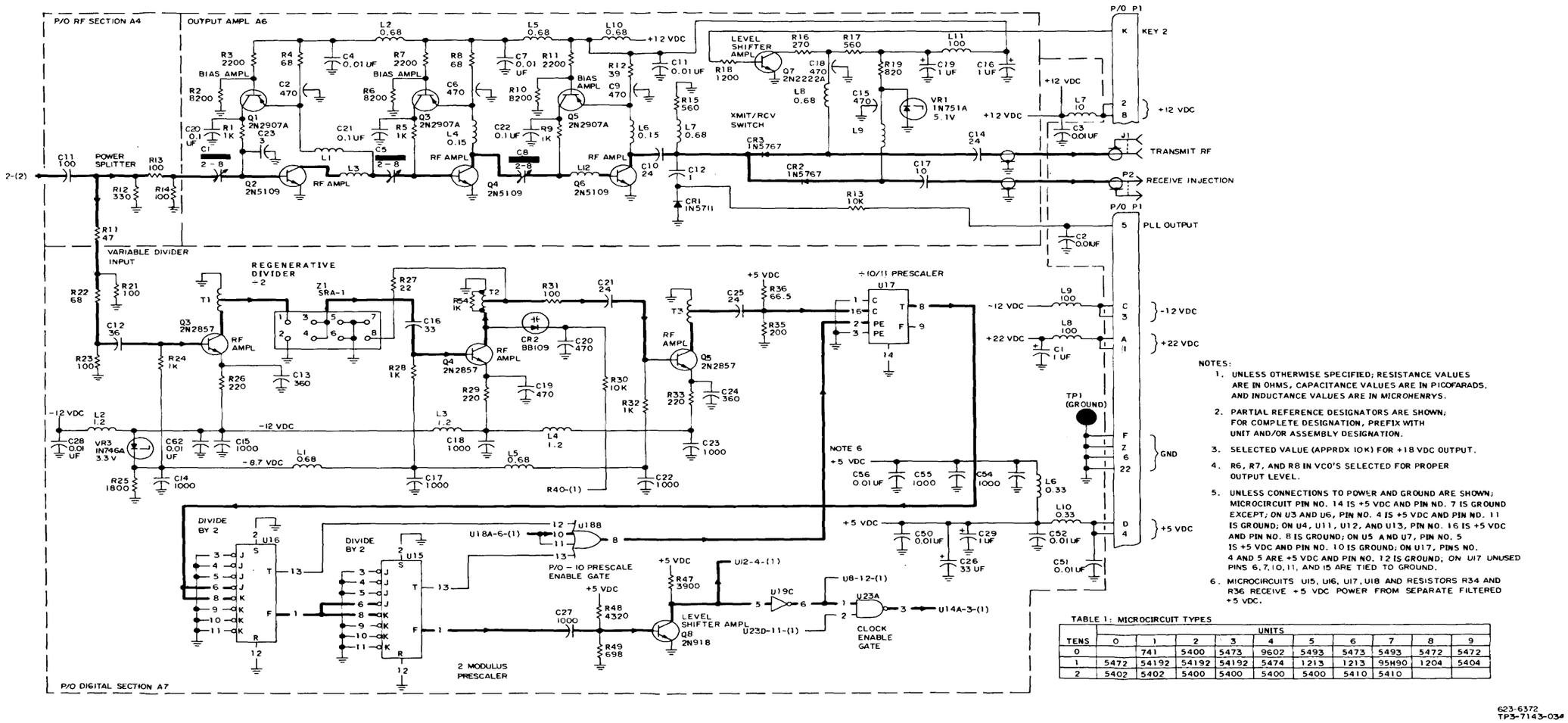
2N2222A 2N2907A 2N2905A	
2N3055	
UA741 MC1558	
5425	

Figure FO-18 D/A Servo Amplifier Module A1, Schematic Diagram (Sheet 3 of 3)



NOTES:

1. UNLESS OTHERWISE SPECIFIED; RESISTANCE VALUES ARE IN OHMS, CAPACITANCE VALUES ARE IN PICOFARADS, AND INDUCTANCE VALUES ARE IN MICROHENRYS.
2. PARTIAL REFERENCE DESIGNATORS ARE SHOWN; FOR COMPLETE DESIGNATION, PREFIX WITH UNIT AND/OR ASSEMBLY DESIGNATION.
3. SELECTED VALUE (APPRDX 10K) FOR +18 VDC OUTPUT.
4. R6, R7, AND R8 IN VCO'S SELECTED FOR PROPER OUTPUT LEVEL.
5. UNLESS CONNECTIONS TO POWER AND GROUND ARE SHOWN; MICROCIRCUIT PIN NO. 14 IS +5 VDC AND PIN NO. 7 IS GROUND EXCEPT; ON U3 AND U6, PIN NO. 4 IS +5 VDC AND PIN NO. 11 IS GROUND; ON U4, U11, U12, AND U13, PIN NO. 16 IS +5 VDC AND PIN NO. 8 IS GROUND; ON U5 AND U7, PIN NO. 5 IS +5 VDC AND PIN NO. 10 IS GROUND; ON U17, PINS NO. 4 AND 5 ARE +5 VDC AND PIN NO. 12 IS GROUND; ON U17 UNUSED PINS 6, 7, 10, 11, AND 15 ARE TIED TO GROUND.
6. MICROCIRCUITS U15, U16, U17, U18 AND RESISTORS R34 AND R36 RECEIVE +5 VDC POWER FROM SEPARATE FILTERED +5 VDC.

TABLE 1: MICROCIRCUIT TYPES

TENS	UNITS 0	1	2	3	4	5	6	7	8	9
0		741	5400	5473	9602	5493	5473	5493	5472	5472
1	5472	54192	54192	54192	5474	1213	1213	95H90	1204	5404
2	5402	5402	5400	5400	5400	5400	5410	5410		

623-6372
TP3-7143-034

Figure FO-19. Frequency Synthesizer Module A2, Schematic Diagram (Sheet 3 of 4)

VOLTAGE AND RESISTANCE MEASUREMENTS AND TEST CONDITIONS

Typical voltage measurements and waveforms were obtained under the following conditions unless noted otherwise:

Dc measurements were taken with Fluke 8000A-01 Digital Multimeter; waveforms were taken with Oscilloscope MIL-O-9960C. Ground reference point was ground test point on module. Module was extended to take voltage measurements.

Resistance measurements were taken with Fluke 8000A-01 Digital Multimeter. Unless otherwise noted, measurements were taken on 20-kΩ range with module ground test point as ground reference. Module was removed from chassis to take resistance measurements.

AN/GRC-171 Test Conditions

Input power: 120 V ac, 60 Hz

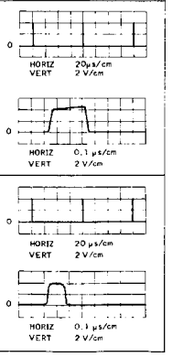
Receive mode

Front panel control settings

REMOTE/LOCAL switch	LOCAL
SQUELCH switch	OFF
PTT/CARRIER TEST switch	PTT
FREQUENCY switches	300.000 MHz

Voltages, resistances, and waveforms are not absolute and may vary between radio sets because of normal differences in component characteristics.

A2A7 TEST POINT VOLTAGE REQUIREMENTS

TP1	GROUND
TP2	18 V dc
TP3	
TP4	

A2A7 TEST POINT AND TRANSISTOR VOLTAGE MEASUREMENTS

RADIO CONTROL FREQUENCY (MHZ)	RECEIVE MODE 225.000 THRU 279.975	RECEIVE MODE 280.000 THRU 349.975	RECEIVE MODE 350.000 THRU 399.975	TRANSMIT MODE 225.000 THRU 249.975	TRANSMIT MODE 250.000 THRU 319.973	TRANSMIT MODE 320.000 THRU 399.975
TP/LEAD	V DC	V DC	V DC	V DC	V DC	V DC
TP5	+3.2	+0.07	+0.07	+3.2	+0.07	+0.07
TP6	+0.07	+3.2	+0.07	−0.07	+3.20	+0.07
TP7	+0.07	+0.07	+3.2	+0.07	+0.07	+3.2
A2A7Q6-E	0	0	0	0	0	0
-B	+0.07	+0.7	+0.07	+0.07	+0.7	+0.07
-C	+6.2	+0.05	+13	+2	+0.05	+13
A2A7Q7-E	0	0	0	0	0	0
-B	+0.7	+0.07	+0.07	+0.7	+0.07	+0.07
-C	+0.05	+8	+13	+0.05	+8	+13

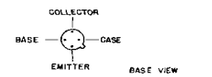
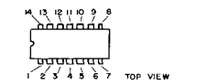
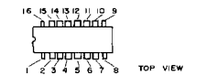
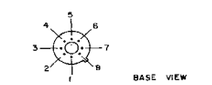
A2A7 TRANSISTOR VOLTAGE AND RESISTANCE MEASUREMENTS

LEAD	VOLTAGE (V dc) E	B	C	RESISTANCE (ohms) E	B	C
A2A7Q1	+18	+18.7	+21.2	5000	6600	15 kΩ
A2A7Q2	0	+0.13	+2.8	0	8700	11 kΩ
A2A7Q3	-9.9	-9.2	0	13 kΩ	6400	0
A2A7Q4	-9.9	-9.2	0	13 kΩ	6300	0
A2A7Q5	-9.9	-9.2	0	13 kΩ	6100	0
A2A7Q6	0	+0.7	+0.05	0	6100	21 kΩ
A2A7Q7	0	+0.07	+8	0	6000	16 kΩ

A2A7 INTEGRATED CIRCUIT VOLTAGE MEASUREMENT

A2A7U1 PIN	V DC
1	0
2	+5.1
3	+5.1
4	0
5	0
6	+10.7
7	22
8	0

PIN LOCATION DIAGRAM

2N2219A 2N2222A 2N2369A 2N2907A 2N5109	
2N918 2N2857	
1204 1213 5400 5402 5404 5410 5472 5473 5474 5493	
54192 95H90 9602	
741	

A2A7 INTEGRATED CIRCUIT RESISTANCE MEASUREMENTS

PIN	RESISTANCE (ohms) U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11	U12	U13	U14	U15	U16	U17	U18	U19	U20	U21	U22	U23	U24	U25	U26	U27	PIN
1	1000	*	5900	1650	*	*5900	*	*	*	*	*	*	*	*	1330	1380	0	910	*	*	*	700	*	*	*	*	*	1
2	3150	8700	*	7700	*	*	*	*	*	*	*	*	*	*	0	0	800	910	*	*	*	2100	*	*	*	*	*	2
3	16 kΩ	*	0	*	0	*	0	*	*	*	*	*	*	*	0	0	0	910	*	*	*	*	*	*	*	*	*	3
4	0	8700	230	1000	*	230	*	*	*	*	*	4150	*	*	0	0	230	910	*	*	6600	*	*	*	*	*	*	4
5	970	*	2100	*	230	2100	230	*	*	*	*	*	*	*	0	0	230	1500	4150	*	8100	2100	2100	*	*	*	*	5
6	10.5 kΩ	*	*	5900	*	5900	*	*	*	*	*	*	*	*	1380	1700	0	1500	*	*	6600	*	*	*	*	*	6000	6
7	15 kΩ	0	2100	5900	*	8700	*	0	0	0	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
8	*	*	*	0	*	*	*	2100	*	*	0	0	0	*	1380	1700	1700	820	2100	*	*	*	*	*	*	*	*	8
9	NC	*	*	5900	*	*	*	*	*	*	*	*	*	*	0	0	1700	1500	*	*	*	2100	*	*	*	*	*	9
10	NC	*	0	5900	0	*	0	*	*	*	*	*	*	*	0	0	0	1500	*	*	*	*	2100	*	*	*	*	10
11	NC	8700	0	*	*	0	*	*	*	*	*	*	*	*	0	0	0	1500	*	*	*	*	*	*	*	*	*	11
12	NC	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	1500	*	*	*	2100	*	*	*	*	8100	12
13	NC	*	*	*	*	*	*	*	*	*	*	*	*	*	1400	1450	*	1400	*	*	*	700	*	*	*	*	*	13
14	NC	230	5900	5500	*	*	570	230	230	230	0	0	0	230	230	230	0	230	230	230	230	230	230	230	230	230	230	14
15	NC	NC	NC	1700	NC	NC	NC	NC	NC	NC	*	*	*	NC	NC	NC	0	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	15
16	NC	NC	NC	230	NC	NC	NC	NC	NC	NC	230	230	230	NC	NC	NC	170	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	16

* >2 MΩ
NC - No connection

Figure FO-19. Frequency Synthesizer Module A2, Schematic Diagram (Sheet 4 of 4)

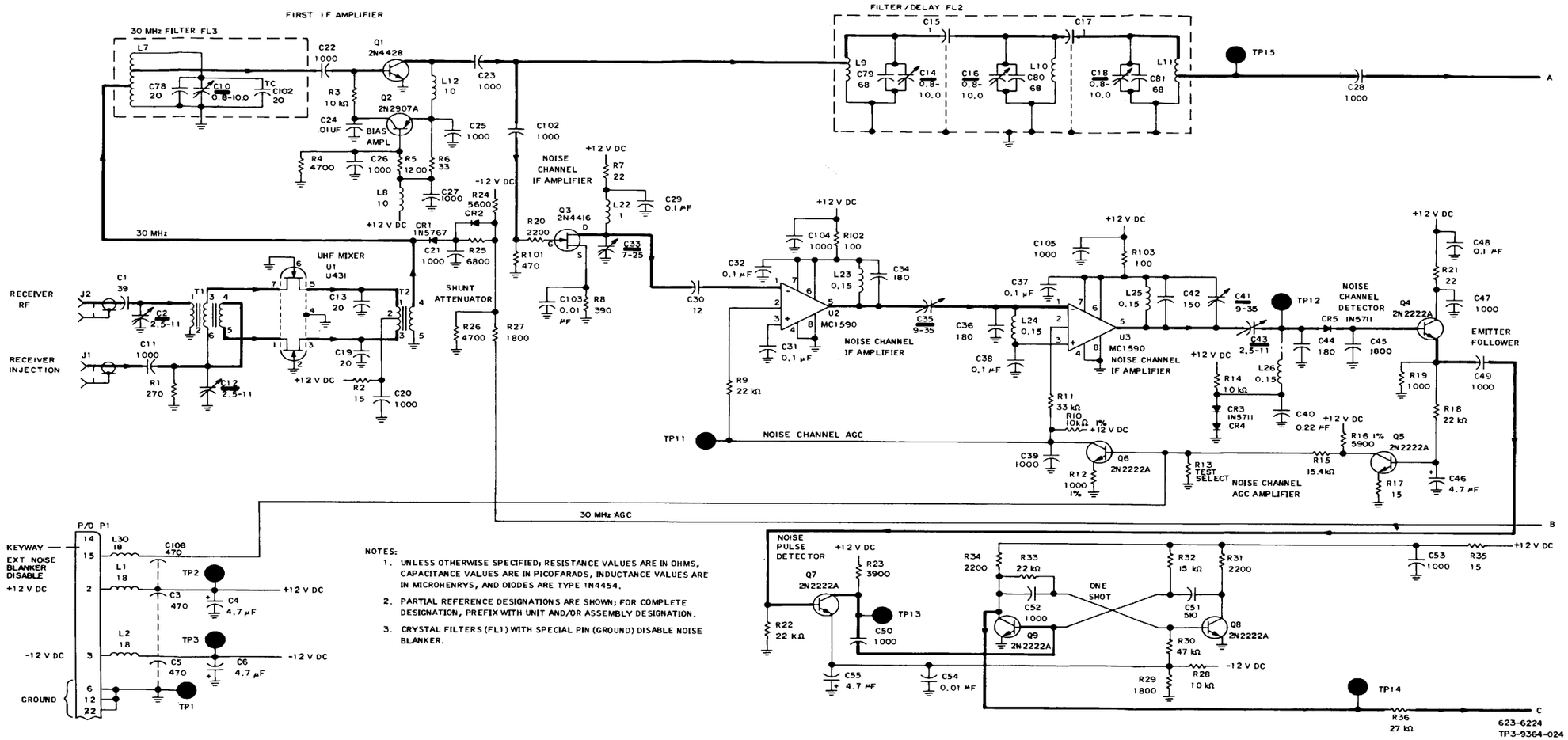


Figure FO-20. Receiver RF Module A3, Schematic Diagram (Sheet 1 of 3)

6-61/(6-62 blank)

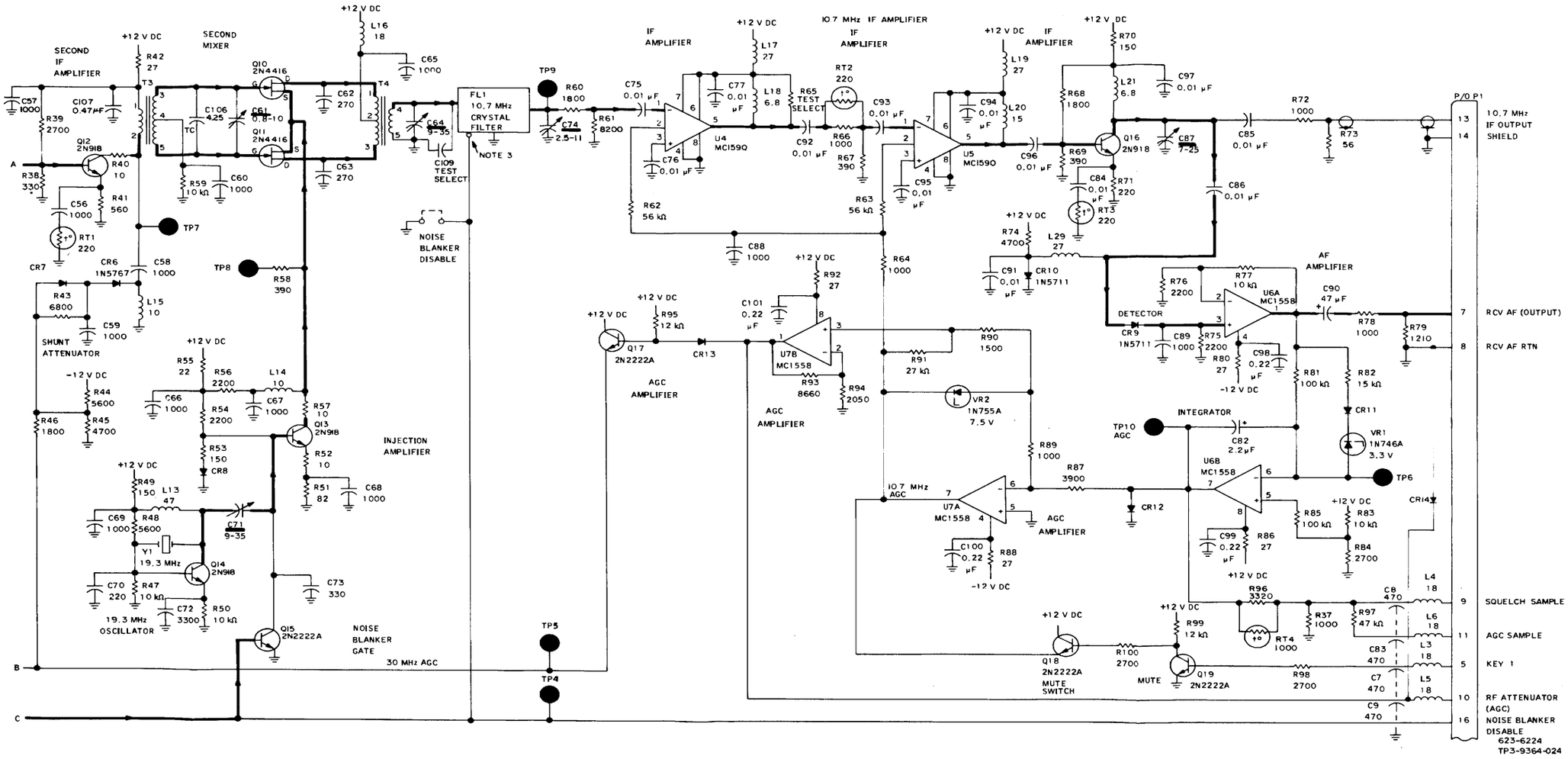


Figure FO-20. Receiver RF Module A3, Schematic Diagram (Sheet 2 of 3)

VOLTAGE AND RESISTANCE MEASUREMENTS AND TEST CONDITIONS

Typical voltage measurements were obtained under the following conditions unless noted otherwise:

Dc measurements were taken with Fluke 8000A-01 Digital Multimeter. Ground reference point was ground test point on module. Module was extended to take voltage measurements.

Resistance measurements were taken with Fluke 8000A-01 Digital Multimeter. Unless otherwise noted, measurements were taken on 20-kΩ range with module ground test point as ground reference. Module was removed from chassis to take resistance measurements.

AN/GRC-171 Test Conditions

Input power: 120 V ac, 60 Hz

Receive mode

Input rf signal at antenna	
Frequency	300.000 MHz
Level	1 mV
Modulation	1000 Hz, 30%
Output connections	
Main audio output	Terminated into 600 ohms
Headset jack	Terminated into 600 ohms
Front panel control settings	
REMOTE/LOCAL switch	LOCAL
SQUELCH switch	OFF
PTT/CARRIER TEST switch	PTT
FREQUENCY switches	300.000 MHz
RCV AUDIO control	100 mW into 600 ohms at main audio output
VOL control	1 mW into 600 ohms at headset jack

Transmit mode

Input audio signal at main audio input	
Frequency	1000 Hz
Level	245 mV ac across 600 ohms (+10 dB mW)
Output connections	
Antenna jack	Terminated into 50 ohms
Main audio output	Terminated into 600 ohms

Front panel control settings

REMOTE/LOCAL	LOCAL
SQUELCH	OFF
FREQUENCY	300.000 MHz
PTT/CARRIER TEST	CARRIER TEST
% MOD	90% modulation (front panel meter)
SIDETONE	100 mW into 600 ohms at main audio output

Voltages and resistances are not absolute and may vary between radio sets because of normal differences in component characteristics.

A3 TRANSISTOR VOLTAGE AND RESISTANCE MEASUREMENTS

	LEAD	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19
		VOLTAGE (V dc)																		
RECEIVE MODE	E (S)	0	+9.9	(+1.6)	+0.5	0	+0.7	-0.7	0	0	(+2.6)	(+2.6)	+0.6	+0.6	+6.9	0	+1.1	+6.5	+8.1	0
	B (G)	+0.7	-9.4	(0)	+1.1	+0.5	+1.3	-0.1	-0.17	+0.7	(0)	(0)	-1.3	+1.3	+7.3	+0.05	+1.8	+7.2	+0.2	+0.7
	C (D)	+9.9	+2.4	(+11.8)	+11.9	+8.9	+5.3	+9.0	+11.9	+0.05	(+11.9)	(+11.9)	+11.8	+2.6	+11.6	+1.3	+10.4	+11.9	+11.9	+0.05
TRANSMIT MODE	E (S)	0	+10	(+1.6)	+0.2	0	+0.7	0	0	0	(+2.6)	(+2.6)	+0.6	+0.6	+6.9	0	+1.1	+10.5	+9.5	0
	B (G)	+0.7	+9.4	(0)	+0.8	+0.2	+1.3	-0.1	-0.17	+0.7	(0)	(0)	+1.3	+1.3	+7.3	+0.05	+1.8	+11.1	+10.1	+0.07
	C (D)	+9.8	+2.4	(+11.9)	+11.9	+9	+5.3	+9	+11.9	+0.05	(+11.9)	(+11.9)	+11.8	+2.6	+11.6	+1.3	+10.4	+11.9	+11.9	+10.5
		RESISTANCE (ohms)																		
	E (S)	0	200	(200)	1000	15	1000	1600	0	0	(240)	(240)	530	92	9 kΩ	0	220	2900	5900	0
	B (G)	6100	1100	(2670)	6100	5900	2300	6500	5800	5800	(5700)	(5700)	290	2400	3500	5800	330	5600	5700	5900
	C (D)	200	5900	(170)	190	4500	6500	3800	2300	2300	(170)	(170)	200	250	320	2400	290	170	160	6800

A3 INTEGRATED CIRCUIT VOLTAGE AND RESISTANCE MEASUREMENTS

	PIN	U1	U2	U3	U4	U5	U6	U7
		VOLTAGE (V dc)						
RECEIVE MODE	1	+2.4	+3.6	+3.5	+3.9	+4	+2.6	+6.6
	2	0	+5.2	+5.2	+5.9	+5.9	+0.5	+1.3
	3	+11.8	+3.6	+3.5	+3.9	+4	+0.5	+1.3
	4	0	0	0	0	0	-11.9	-11.9
	5	+11.8	+10.7	+10.7	+11.8	+11.8	+2.6	0
	6	+2.4	+10.7	+10.7	+11.8	+11.8	+2.6	0
	7	+2.4	+10.7	+10.7	+11.8	+11.8	-3.4	+8
	8	NC	0	0	0	0	+11.8	+11.8
TRANSMIT MODE	1	+2.4	+3.6	+3.5	+3.9	+4	+0.8	+10.9
	2	0	+5.2	+5.2	+5.9	+5.9	+0.1	+2.1
	3	+11.8	+3.6	+3.5	+3.9	+4	+0.15	+2.7
	4	0	0	0	0	0	-11.9	-11.5
	5	+11.8	+10.7	+10.7	+11.8	+11.8	+2.6	0
	6	0	+10.7	+10.7	+11.8	+11.8	+0.8	+2
	7	+2.4	+10.7	+10.7	+11.8	+11.8	+0.8	+9.5
	8	NC	0	0	0	0	+11.3	+11.8
		RESISTANCE (ohms)						
	1	160	6300	5900	6200	6200	5900	5700
	2	0	6000	6000	6000	6100	2100	2100
	3	160	6300	5900	6200	6200	2100	7400
	4	0	0	0	0	0	3400	3400
	5	160	270	270	170	170	*103 kΩ	0
	6	0	270	270	170	170	*109 kΩ	5400
	7	160	270	270	170	170	1800	5900
	8	NC	0	0	0	0	200	200

*Measured on 2000-kΩ range.

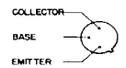
A3 TEST POINT VOLTAGE AND RESISTANCE MEASUREMENTS

TEST POINT	VOLTAGE (V dc) RECEIVE MODE	VOLTAGE (V dc) TRANSMIT MODE	RESISTANCE (ohms)
1	0	0	0
2	+11.9	+11.9	170
3	-12	-12	3400
4	+0.05	+0.05	5800
5	+6.5	+10.5	2900
6	+2.6	+0.8	*109 kΩ
7	+11.8	+11.8	190
8	+3	+3	630
9	0	0	0
10	-3.4	+0.7	1800
11	+5.3	+5.3	6500
12	+1	+1	6800
13	+9	+9	3800
14	+0.05	+0.05	2300
15	0	0	0

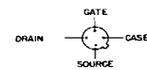
*Measured on 2000-kΩ range.

PIN LOCATION DIAGRAMS

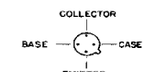
2N2222A
2N2907A
2N4428



2N4416



2N918



U431
MC1558
MC1590

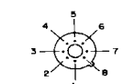


Figure FO-20. Receiver RF Module A3, Schematic Diagram (Sheet 3 of 3)

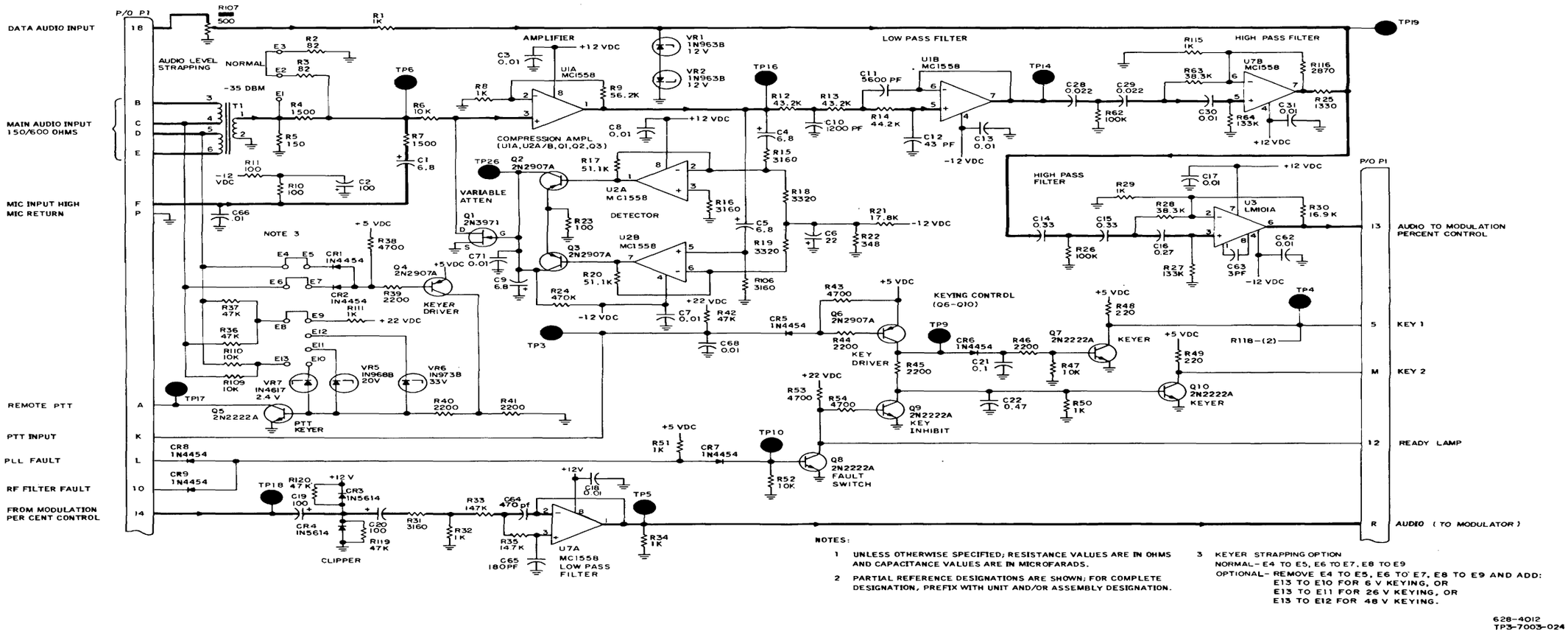


Figure FO-21 . Audio Module A4, Schematic Diagram
(Sheet 1 of 3)

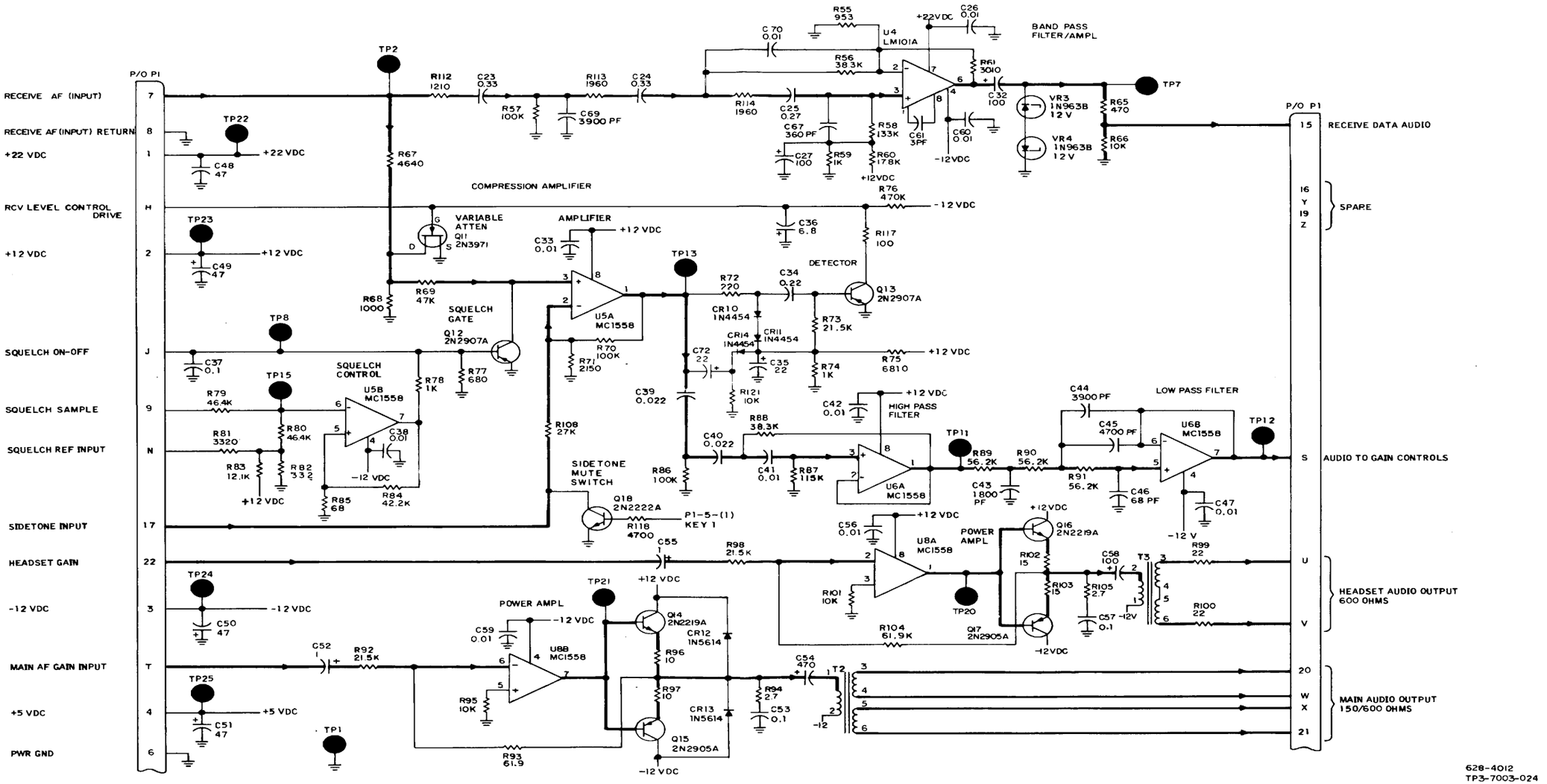


Figure FO-21 . Audio Module A4, Schematic Diagram (Sheet 2 of 3)

VOLTAGE AND RESISTANCE MEASUREMENTS AND TEST CONDITIONS

Typical voltage measurements were obtained under the following conditions unless noted otherwise:

Ac and dc measurements were taken with Fluke 8000A-01 Digital Multimeter. Ground reference point was ground test point on module. Module was extended to take voltage measurements.

Resistance measurements were taken with Fluke 8000A-01 Digital Multimeter. Unless otherwise noted, measurements were taken on 20-kΩ range with module ground test point as ground reference. Module was removed from chassis to take resistance measurements.

AN/GRC-171 Test Conditions

Input power: 120 V ac, 60 Hz

Receiver mode

Input rf signal at antenna	
Frequency	300.000 MHz
Level	1 mV
Modulation	1000 Hz, 30%
Output connections	
Main audio output	Terminated into 600 ohms
Headset jack	Terminated into 600 ohms
Front panel control settings	
REMOTE/LOCAL switch	LOCAL
SQUELCH switch	OFF
PTT/CARRIER TEST switch	PTT
FREQUENCY switches	300.000 MHz
RCV AUDIO control	100 mW into 600 ohms at main audio output
VOL control	1 mW into 600 ohms at headset jack

Transmit mode

Input audio signal at main audio input	
Frequency	1000 Hz
Level	245 mV ac across 600 ohms (-10 dB mW)
Output connections	
Antenna jack	Terminated into 50 ohms
Main audio output	Terminated into 600 ohms

Front panel control settings

REMOTE/LOCAL	LOCAL
SQUELCH	OFF
FREQUENCY	300.000 MHz
PTT/CARRIER TEST	CARRIER TEST
%MOD	90% modulation (front panel meter)
SIDETONE	100 mW into 600 ohms at main audio output

Voltages and resistances are not absolute and may vary between radio sets because of normal differences in component characteristics.

A4 TRANSISTOR VOLTAGE AND RESISTANCE MEASUREMENTS

	LEAD	VOLTAGE																			
		Q1		Q2		Q3		Q4		Q5		Q6		Q7		Q8		Q9		Q10	
		V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac
RECEIVE MODE	E (S)	(0)	(0)	0	0	0	0	+5.1	0	0	0	+5.1	0	0	0	0	0	0	0	0	0
	B (G)	(-11.5)	(0)	+2.9	0	+2.9	0	+5.1	0	0	0	+5.1	0	0	0	+0.75	0	-0.06	0	0	0
	C (D)	(0)	(0)	-11.5	0	-11.5	0	0	0	0	0	0	0	+4.6	0	+0.06	0	0	0	+4.6	0
TRANSMIT MODE	E (S)	(0)	(0)	0	0.02	0	0.02	+5.1	0	0	0	+5.1	0	0	0	0	0	0	0	0	0
	B (G)	(-2.5)	(0)	-2.9	2.5	+2.9	2.5	+5.1	0	0	0	+4.4	0	+0.75	0	+0.75	0	+0.07	0	+0.75	0
	C (D)	(0)	(0)	-2.5	0	-2.5	0	0	0	0	0	+5	0	+0.1	0	+0.07	0	+0.1	0	0.1	0

	RESISTANCE (ohms)									
E (S)	(0)	100	100	7500	0	7500	0	0	0	0
B (G)	(11 kΩ)	8000	7000	14 kΩ	4400	14 kΩ	5700	5600	6000	1000
C (D)	(40)	11 kΩ	11 kΩ	2200	> 2 MΩ	3200	7300	9000	1000	7700

	LEAD	VOLTAGE																			
		Q11		Q12		Q13		Q14		Q15		Q16		Q17		Q18					
		V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac				
RECEIVE MODE	E (S)	(0)	(0)	0	0	0	0	+0.5	2.7	-0.5	2.7	+0.1	0.3	-0.1	0.3	0	0				
	B (G)	(-3.7)	(0.06)	0	0	+1.3	1.5	0	4	0	4	0	1.1	0	1.1	+0.75	0				
	C (D)	(0)	(0.02)	0	0.03	-3.7	0.01	+12	0	-12	0	+12	0	-12	0	+0.1	0				
TRANSMIT MODE	E (S)	(0)	(0)	0	0	0	0	+0.5	2.7	-0.5	2.7	+0.1	0.3	-0.1	0.3	0	0				
	B (G)	(-3.7)	(0)	0	0	+1.6	1.5	0	4	0	4	0	1.1	0	1.1	0	0				
	C (D)	(0)	(0)	0	0	-2.7	0.26	+12	0	-12	0	+12	0	-12	0	0	1				

	RESISTANCE (ohms)							
E (S)	(0)	0	0	8000	8000	10 kΩ	10 kΩ	0
B (G)	(7000)	680	*22.5 kΩ	9000	9000	9000	9000	6000
C (D)	(30)	6000	8000	4000	5000	4000	5000	*70 kΩ

*Measured on 2000-kΩ range.

A4 INTEGRATED CIRCUIT VOLTAGE AND RESISTANCE MEASUREMENTS

	PIN	VOLTAGE															
		U1		U2		U3		U4		U5		U6		U7		U8	
		V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac	V dc	V ac
RECEIVE MODE	1	+0.04	0	+2.9	0	-10.7	0	-10.7	0	0	1.4	0	1.4	0	0	0	1.1
	2	0	0	0	0	0	0	+0.64	0.2	0	0.033	0	1.4	0	0	0	0
	3	0	0	0	0	0	0	+0.64	0.2	0	0.033	0	1.3	0	0	0	0
	4	-12	0	-12	0	-12	0	-12	0	-12	0	-12	0	-12	0	-12	0
	5	0	0	0	0	-10.8	0	-10.8	0	+0.018	0	0	1.3	0	0	0	0
	6	0	0	0	0	0	0	+2.6	0.9	-0.8	0	0	1.4	0	0	0	0
	7	0	0	+2.9	0	-12	0	+22	0	+10.7	0	0	1.4	0	0	0	4
	8	+12	0	+12	0	-0.7	0	+2.1	0.9	+12	0	+12	0	+12	0	+12	0
TRANSMIT MODE	1	+0.06	0.15	+2.9	2.5	-10.7	0	-10.7	0	0	1.4	0	1.4	0	0.78	0	1.1
	2	0	0	0	0	0	0.29	+0.64	0	0	0	0	1.4	0	0.78	0	0
	3	0	0	0	0	0	0.29	+0.64	0	0	0	0	1.3	0	0.75	0	0
	4	-12	0	-12	0	-12	0	-12	0	-12	0	-12	0	-12	0	-12	0
	5	+0.06	0.16	0	0.13	-10.8	0	-10.8	0	-0.014	0	0	1.3	0	0	0	0
	6	+0.06	0.14	0	0.13	-0.05	5.3	+2.6	0	+0.4	0	0	1.4	0	0	0	0
	7	+0.06	0.14	+2.9	2.5	+12	0	+22	0	-9.3	0	0	1.4	-0.1	0.6	0	4
	8	+12	0	+12	0	-0.6	5.4	+2.1	0	+12	0	+12	0	+12	0	+12	0

	RESISTANCE (ohms)							
1	7500	6000	18 kΩ	15 kΩ	7500	7500	1000	9000
2	1000	3700	1000	680	2150	7500	1000	8000
3	40	3160	7000	14 kΩ	6000	8000	8000	7000
4	5000	5000	5000	5000	5000	5000	5000	5000
5	8000	3160	18 kΩ	18 kΩ	68	8000	8000	7000
6	7500	3700	7000	5100	7500	7500	850	8000
7	7500	7000	4000	9000	1600	7500	1600	9000
8	4000	4000	11 kΩ	11 kΩ	4000	4000	4000	4000

A4 TEST POINT VOLTAGE AND RESISTANCE MEASUREMENTS

TEST POINT	RCV MODE		XMT MODE		RESISTANCE (ohms)	TEST POINT	RCV MODE		XMT MODE		RESISTANCE (ohms)
	V dc	V ac	V dc	V ac			V dc	V ac	V dc	V ac	
1	0	0	0	0	0	14	0	0	+0.06	0.14	7500
2	0	0.25	0	0	4680	15	+0.8	0	+0.4	0	7500
3	+22	0	0	0	*480 kΩ	16	+0.04	0	+0.06	0.15	7500
4	+4.6	0	-0.1	0	7300	17	0	0	0	0	> 2 MΩ
5	0	0	0	0.78	1000	18	-0.1	0	-0.1	3.1	*1.8 MΩ
6	0	0	0	0.015	150	19	-0.06	0	-0.06	0.29	1200
7	0	0.9	0	0	10.5 kΩ	20	0	1.1	0	1.1	9000
8	0	0	0	0	680	21	0	4	0	4	9000
9	0	0	+5	0	3200	22	+22	0	+22	0	9000
10	+0.75	0	+0.75	0	5600	23	+12	0	+12	0	4000
11	0	1.4	0	1.4	7500	24	-12	0	-12	0	5000
12	0	1.4	0	1.4	7500	25	+5.1	0	+5.1	0	7500
13	0	1.4	0	1.4	7500	26	-11.5	0	-2.5	0	11 kΩ

*Measured on 2000-kΩ range.

PIN LOCATION DIAGRAMS

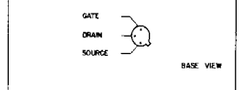
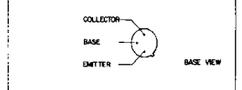
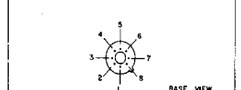
2N3971	
2N2219A 2N2222A 2N2905A 2N2907A	
LM101A MC1558	

Figure FO-21 . Audio Module A4, Schematic Diagram (Sheet 3 of 3)

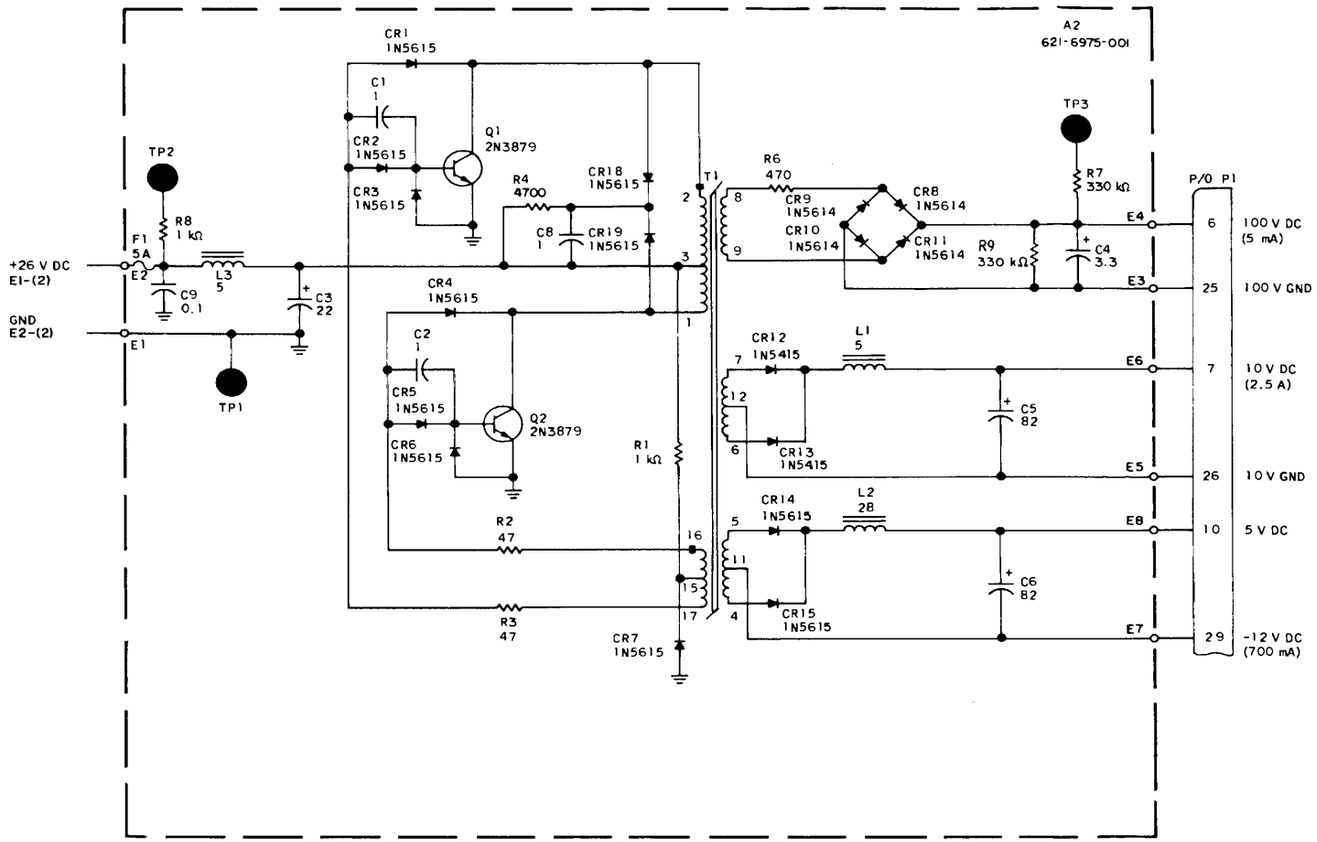


Figure FO-22 . DC-DC Converter Module A5, Schematic Diagram (Sheet 1 of 3)

TABLE 1: MICROCIRCUIT TYPES

TENS	UNITS									
	0	1	2	3	4	5	6	7	8	9
0		5473	555V	711	1558	5440	1558			
1										

NOTE:

1. UNLESS OTHERWISE SPECIFIED; RESISTANCE VALUES ARE IN OHMS, CAPACITANCE VALUES ARE IN MICROFARADS, INDUCTANCE VALUES ARE IN MICROHENRYS, AND DIODES ARE TYPE 1N4454.
2. PARTIAL REFERENCE DESIGNATORS ARE SHOWN; FOR COMPLETE DESIGNATION, PREFIX WITH UNIT AND/OR ASSEMBLY DESIGNATION.
3. UNLESS CONNECTION TO POWER AND GROUND ARE SHOWN; PIN NO. 4 IS +5.1 V DC PIN NO. 11 IS GROUND EXCEPT ON U5 PIN NO. 14 IS +5.1 V DC AND PIN NO. 7 IS GROUND.
4. ENCLOSED TRANSISTORS ARE MOUNTED ON A HEAT SINK.
5. CR6 & P1-28 INCORPORATED IN MODULES MCN 110 & UP.
6. MEASUREMENT OF CURRENT SENSE LINE MAY RESULT IN DAMAGE TO EQUIPMENT.

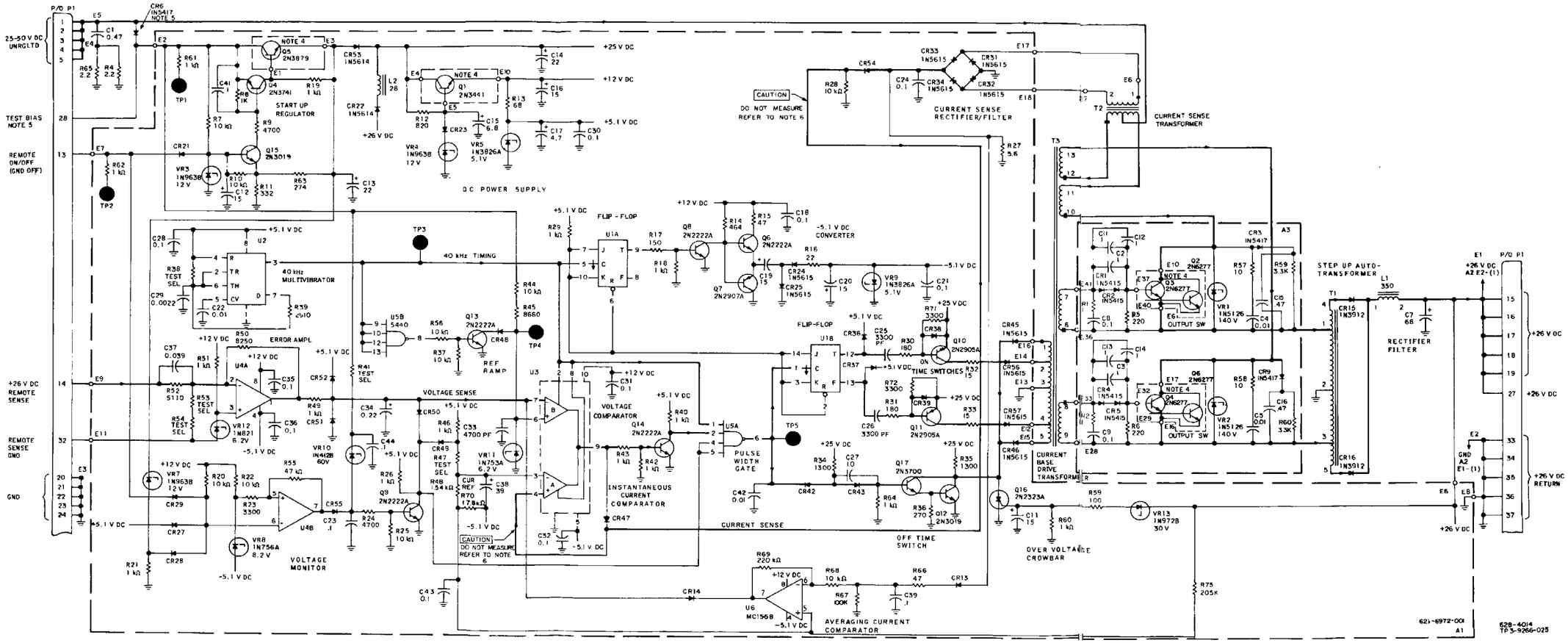


Figure FO-22 . DC-DC Converter Module A5, Schematic Diagram (Sheet 2 of 3)

VOLTAGE AND RESISTANCE MEASUREMENTS AND TEST CONDITIONS

Typical voltage measurements and waveforms were obtained under the following conditions unless noted otherwise:

Ac and dc measurements were taken with Fluke 8000A-01 Digital Multimeter; waveforms were taken with Oscilloscope MIL-O-9960C. Ground reference point was ground test point on module. Module was extended to take voltage measurements.

Resistance measurements were taken with Fluke 8000A-01 Digital Multimeter. Unless otherwise noted, measurements were taken on 20-kΩ range with module ground test point as ground reference. Module was removed from chassis to take resistance measurements.

AN/GRC-171 Test Conditions

Input power: 120 V ac, 60 Hz

Receive mode

Front panel control settings	
REMOTE/LOCAL switch	LOCAL
SQUELCH switch	OFF
PTT/CARRIER TEST switch	PTT
FREQUENCY switches	300.000 MHz

Transmit mode

Output connections	
Antenna jack	Terminated into 50 ohms
Front panel control settings	
REMOTE/LOCAL	LOCAL
SQUELCH	OFF
FREQUENCY	300.000 MHz
PTT/CARRIER TEST	CARRIER TEST

Voltages, resistances, and waveforms are not absolute and may vary between radio sets because of normal differences in component characteristics.

A5A1 TRANSISTOR VOLTAGE AND RESISTANCE MEASUREMENTS

LEAD	VOLTAGE (V dc)												
	Q4	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17
E (C)	+48.6	+5	+5	0	0	+25.5	+25.5	0	0	0	+11.6	(0)	+0.6
B (G)	+48.3	+5	+5	-0.4	+0.07	+25.3	+25.3	+0.6	+0.2	+0.3	+12.1	(0)	+1.2
C (A)	+21.5	+10.9	0	+5	+5.6	+0.7	+0.7	+6.9	+3.1	+2.5	+48	(+6.9)	+6.9
	RESISTANCE (ohms)												
E (C)	10.7 kΩ	6000	6000	0	0	6900	6900	0	0	0	330	(0)	270
B (G)	11.2 kΩ	7100	7100	1000	5700	10 kΩ	10 kΩ	270	5700	970	5560	(970)	1000
C (A)	1470	6700	0	7100	7600	3900	3900	8200	> 2 MΩ	7600	13.7 kΩ	(8200)	8200

A5A1 INTEGRATED CIRCUIT VOLTAGE AND RESISTANCE MEASUREMENTS

PIN	VOLTAGE (V dc)						RESISTANCE (ohms)					
	U1	U2	U3	U4	U5	U6	U1	U2	U3	U4	U5	U6
1	+3.6	0	0	+3.6	+4.3	NC	9700	0	0	11.8 kΩ	12.4 kΩ	11 kΩ
2	+5.5	+2.5	+4.3	+6.2	+2.5	NC	7600	14 kΩ	12.4 kΩ	*285 kΩ	7600	> 2 MΩ
3	+5.5	+4.3	+3	+6.2	0	NC	7600	12.4 kΩ	11.9 kΩ	7700	> 2 MΩ	> 2 MΩ
4	+5.6	+5.6	[a]	-5.5	+5.6	-5.5	6600	6600	9800	5000	7600	5000
5	+4.3	+3.7	-5.5	+1.8	+5.6	+2	12.4 kΩ	8000	5000	16.8 kΩ	7600	12 kΩ
6	+5.5	+2.5	+3.6	+6.1	+3.6	+2	7600	14 kΩ	17.2 kΩ	5800	9700	**109 kΩ
7	+5.5	+2.1	+3.6	-3.6	0	+5.8	7600	16.5 kΩ	11.6 kΩ	9700	0	*318 kΩ
8	+2.6	5.6	+4.3	+12.3	+0.1	+12.3	> 2 MΩ	6600	12.4 kΩ	6670	15.3 kΩ	6670
9	+1.5	NC	+2.4	NC	+4.3	NC	1150	NC	NC	NC	12.4 kΩ	NC
10	+5.5	NC	+12.3	NC	+4.3	NC	7600	NC	NC	NC	12.4 kΩ	NC
11	0	NC	NC	NC	0	NC	0	NC	NC	NC	> 2 MΩ	NC
12	+2.2	NC	NC	NC	+4.3	NC	12 kΩ	NC	NC	NC	12.4 kΩ	NC
13	+2.2	NC	NC	NC	+4.3	NC	12 kΩ	NC	NC	NC	12.4 kΩ	NC
14	+5.5	NC	NC	NC	+5.6	NC	7600	NC	NC	NC	6600	NC

*Measured on 2-MΩ range. **Measured on 200-kΩ range. [a] Do not measure. NC - No connection.

A5A1 TEST POINT VOLTAGE AND RESISTANCE MEASUREMENTS

TEST POINT	VOLTAGE (V dc)			RESISTANCE (ohms)
	REMOTE OFF	RECEIVE MODE	TRANSMIT MODE	
TP1	+50	+48.6	+44.6	11.7 kΩ
TP2	0	+13.4	+14.3	> 2 MΩ

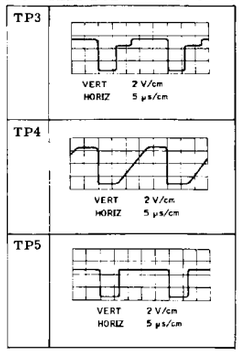
A5A2 TEST POINT VOLTAGE AND RESISTANCE MEASUREMENTS

TEST POINT	VOLTAGE		RESISTANCE (ohms)
	V dc	V ac	
TP1	0	0	0
TP2	+26	0.18	7800
TP3	+104	0.18	> 2 MΩ

A5A3 TRANSISTOR VOLTAGE AND RESISTANCE MEASUREMENTS

LEAD	VOLTAGE (V dc)			
	Q1	Q2/Q3	Q4/Q6	Q5
E	-12.3	0	0	+21.2
B	+13	-0.5	-0.5	+21.5
C	+25.4	+48.6	-48.6	+48.6
	VOLTAGE (V ac)			
E	0.8	15	15	0.9
B	0.8	16	16	0.9
C	1	2.4	2.4	1.8
	RESISTANCE (ohms)			
E	6670	0	0	600
B	7600	220	220	1470
C	6900	4750	4750	10.7 kΩ

A5A1 TEST POINT WAVEFORMS



A5A2 TRANSISTOR VOLTAGE AND RESISTANCE MEASUREMENTS

LEAD	VOLTAGE (V dc)	
	Q1	Q2
E	0	0
B	+0.08	+0.08
C	+26	+26
	VOLTAGE (V ac)	
E	0	0
B	1.4	1.4
C	29	29
	RESISTANCE (ohms)	
E	0	0
B	5000	5000
C	6800	6800

PIN LOCATION DIAGRAMS

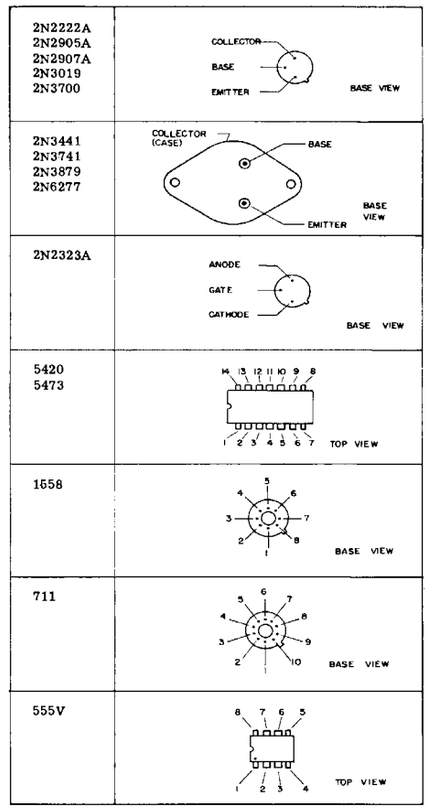
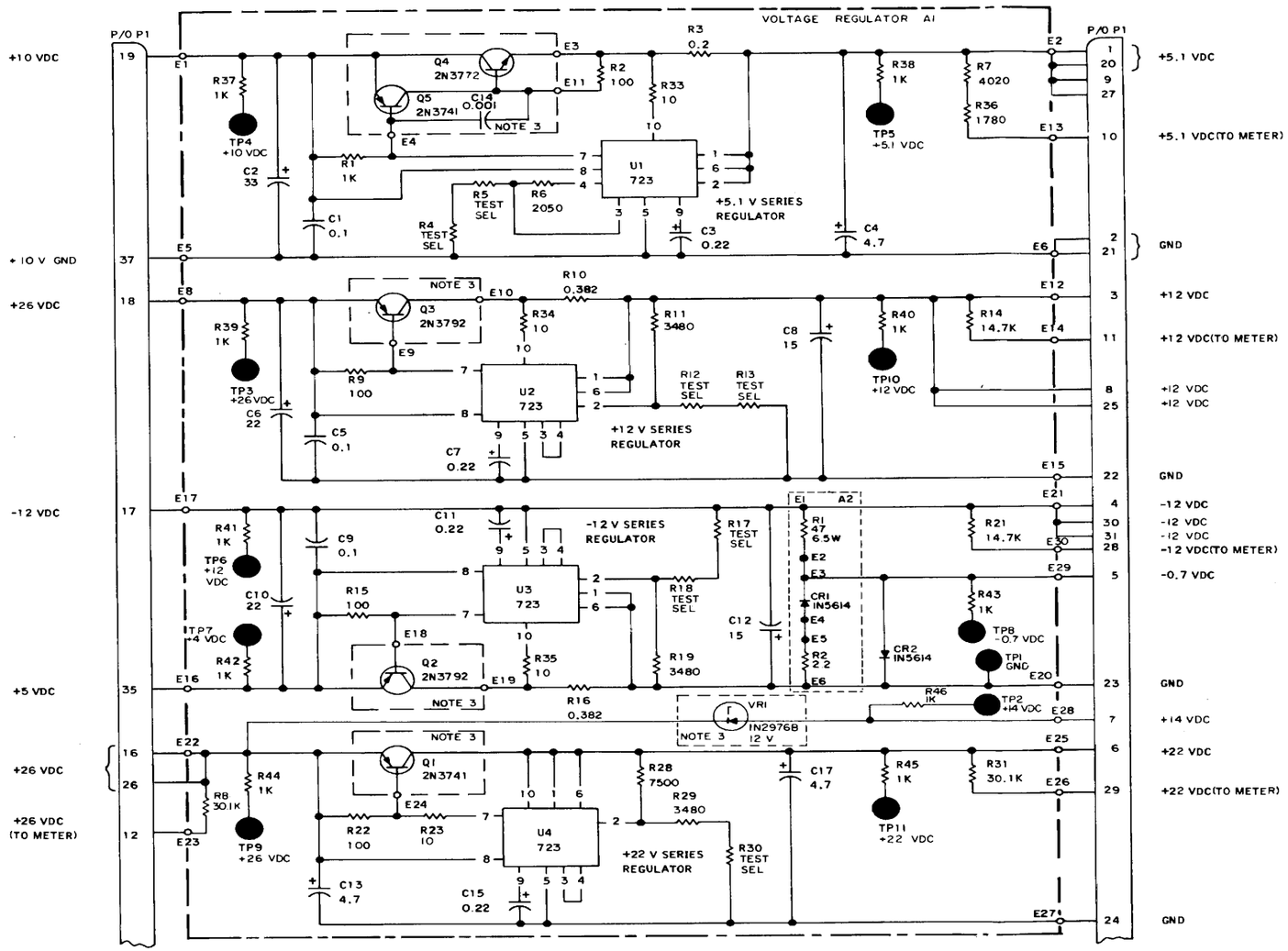


Figure FO-22 . DC-DC Converter Module A5, Schematic Diagram (Sheet 3 of 3)



NOTES:

1. UNLESS OTHERWISE SPECIFIED; RESISTANCE VALUES ARE IN OHMS AND CAPACITANCE VALUES ARE IN MICROFARADS.
2. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN; FOR COMPLETE DESIGNATION, PREFIX WITH UNIT AND/OR ASSEMBLY DESIGNATION.
3. COMPONENTS ENCLOSED IN DASHED LINES ARE MOUNTED ON HEATSINK CASTING, AND ARE HARDWIRED TO BOARD.

Figure FO-23. Voltage Regulator Module A6, Schematic Diagram (Sheet 1 of 2)

VOLTAGE AND RESISTANCE MEASUREMENTS AND TEST CONDITIONS

Typical voltage measurements were obtained under the following conditions unless noted otherwise:

Ac and dc measurements were taken with Fluke 8000A-01 Digital Multimeter. Ground reference point was ground test point on module. Module was extended to take voltage measurements.

Resistance measurements were taken with Fluke 8000A-01 Digital Multimeter. Unless otherwise noted, measurements were taken on 20-kΩ range with module ground test point as ground reference. Module was removed from chassis to take resistance measurements.

AN/GRC-171 Test Conditions

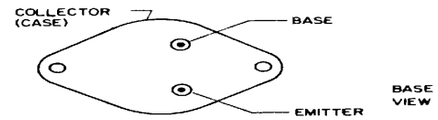
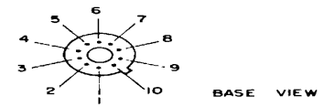
Input power: 120 V ac, 60 Hz

Voltages and resistances are not absolute and may vary between radio sets because of normal differences in component characteristics.

A6 TRANSISTOR VOLTAGE MEASUREMENTS

	V DC				
	Q1	Q2	Q3	Q4	Q5
E	+26	+5.7	+26	+5.4	+10
B	+25.3	+5.0	+25.3	+6.1	+9.3
C	+22	+0.1	+12.2	+10	+6.1

PIN LOCATION DIAGRAMS

2N3741 2N3772 2N3792	
723	

A6 TRANSISTOR AND INTEGRATED CIRCUIT RESISTANCE MEASUREMENTS

[a] +5.1-V SERIES REGULATOR			[b] +12-V SERIES REULATOR			[c] -12-V SERIES REGULATOR			[d] +22-V SERIES		
	1	1000		1	1000		1	0		1	1000
	2	1000		2	4000		2	3400		2	7400
	3	10 kΩ		3	*1600 kΩ		3	*1600 kΩ		3	*1600 kΩ
	4	9000		4	*1600 kΩ		4	*1600 kΩ		4	*1600 kΩ
U1	5	7000	U2	5	7000	U3	5	4300	U4	5	7000
	6	1000		6	1000		6	0		6	1000
	7	*335 kΩ		7	14 kΩ		7	14 kΩ		7	15 kΩ
	8	*335 kΩ		8	14 kΩ		8	14 kΩ		8	15 kΩ
	9	9000		9	9000		9	11 kΩ		9	9000
	10	1010		10	1010		10	10		10	1000
	E	1000		E	14 kΩ		E	14 kΩ		E	15 kΩ
Q4	B	1100	Q3	B	14 kΩ	Q2	B	14 kΩ	Q1	B	15 kΩ
	C	*335 kΩ		C	1000		C	0.4		C	1000
	E	*335 kΩ									
Q5	B	*335 kΩ									
	C	1100									
TP4		*350 kΩ	TP3		*1190kΩ	TP6		5300	TP9		*1190 kΩ
						TP7		*1000 kΩ			
						TP8		5200			

*Measured on 2000-kΩ range.
[a] Multimeter ground reference, TP5.
[b] Multimeter ground reference, TP10.
[c] Multimeter ground reference, TP1.
[d] Multimeter ground reference, TP11.

A6 TEST POINT VOLTAGE MEASUREMENTS

TP	V DC	mV AC
1	0	0
2	+14	
3	+26	140
4	+10	60
5	+5.1	0
6	-12	0
7	+5	140
8	-0.7	0
9	+26	120
10	+12	0
11	+22	0

A6 INTEGRATED CIRCUIT VOLTAGE MEASUREMENTS

	V DC									
	1	2	3	4	5	6	7	8	9	10
U1	+5.1	+5.1	+5.1	+7.15	0	+5.1	+9.3	+10	+6.3	+5.4
U2	+12	+7.14	+7.15	+7.15	0	+12	+25.3	+26	+13.3	+12.2
U3	0	-4.86	-4.85	-4.85	-12	0	+5	+5.7	+1.3	+0.1
U4	+22	+7.14	+7.15	+7.15	0	+22	+25.3	+26	+23.2	+22

Figure FO-23. Voltage Regulator Module A6, Schematic Diagram (Sheet 2 of 2)

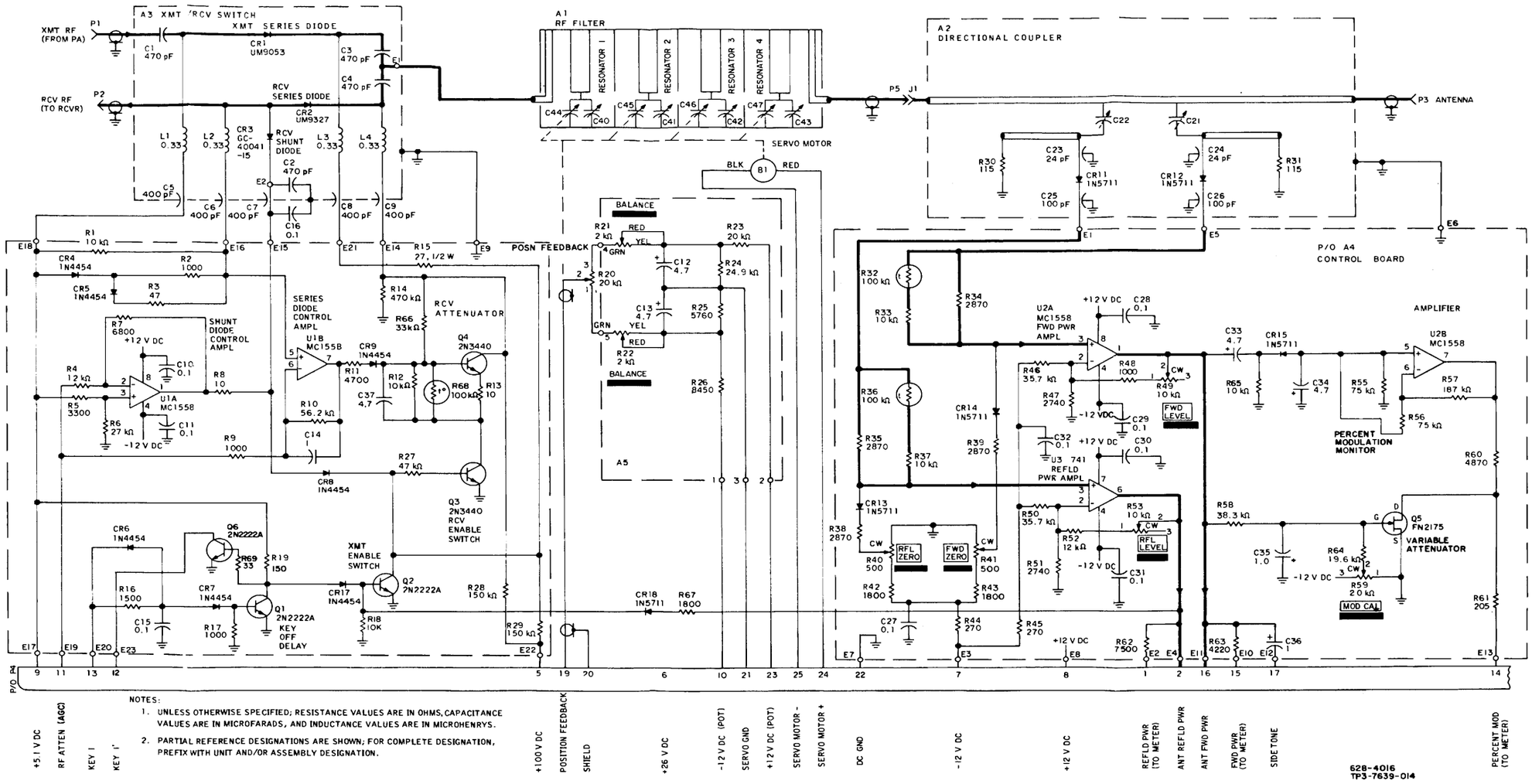


Figure FO-24. RF Filter Module A7, Schematic Diagram (Sheet 1 of 2)

DIODE VOLTAGE MEASUREMENTS (Unless otherwise specified, diodes located on A7A4)

		VOLTAGE (V dc)															
		*CR1	*CR2	*CR3	CR4	CR5	CR6	CR7	CR8	CR9	**CR11	**CR12	CR13	CR14	CR15	CR17	CR18
RECEIVE MODE	CATHODE	+2.7	+3.3	+3.4	+4.5	+4.0	+4.2	+0.7	+28	+0.7	-0.3	-0.3	-1.05	-0.91	0	0	0
	ANODE	+5.1	+4.0	+4.0	+5.1	+4.5	+1.4	+1.4	+3.4	-10	NC	NC	-0.75	-0.62	-0.01	+0.08	+0.13
TRANSMIT MODE	CATHODE	+4.2	+80	+1.0	+4.2	+3.4	+0.1	0	+0.25	+80	-0.2	+2.0	-0.98	+0.19	+0.36	+0.84	+0.84
	ANODE	+5.1	+1.9	+1.9	+5.1	+4.2	+0.1	+0.1	+1.0	-10	NC	NC	-0.70	+0.52	-2.67	+1.5	+0.24

*Located on A7A3. NC - No connection.
**Located on A7A2.

VOLTAGE AND RESISTANCE MEASUREMENTS AND TEST CONDITIONS

Typical voltage measurements were obtained under the following conditions unless noted otherwise:

Dc measurements were taken with Fluke 8000A-01 Digital Multimeter. Ground reference point was ground test point on module. Module was extended to take voltage measurements.

Resistance measurements were taken with Fluke 8000A-01 Digital Multimeter. Unless otherwise noted, measurements were taken on 20-kΩ range with module ground test point as ground reference. Module was removed from chassis to take resistance measurements.

AN/GRC-171 Test Conditions

Input power: 120 V ac, 60 Hz

Receive mode

Input rf signal at antenna	
Frequency	300.000 MHz
Level	1 mV
Modulation	1000 Hz, 30%
Front panel control settings	
REMOTE/LOCAL switch	LOCAL
SQUELCH switch	OFF
PTT/CARRIER TEST switch	PTT
FREQUENCY switches	300.000 MHz

Transmit mode

Input audio signal at main audio input	
Frequency	1000 Hz
Level	245 mV ac across 600 ohms (-10 dB mW)
Output connections	
Antenna jack	Terminated into 50 ohms
Front panel control settings	
REMOTE/LOCAL	LOCAL
SQUELCH	OFF
FREQUENCY	300.000 MHz
PTT/CARRIER TEST	CARRIER TEST
% MOD	90% modulation (front panel meter)

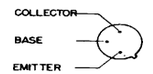
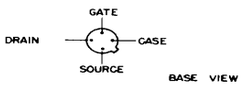
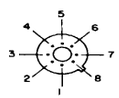
Voltages and resistances are not absolute and may vary between radio sets because of normal differences in component characteristics.

A7A4 INTEGRATED CIRCUIT VOLTAGE AND RESISTANCE MEASUREMENTS

	PIN	VOLTAGE (V dc)			VOLTAGE (V ac)	
		U1	U2	U3	U2	U3
RECEIVE MODE	1	+3.4	+0.02	-12	0	0
	2	+4.6	-0.62	-0.75	0	0
	3	+4.6	-0.62	-0.75	0	0
	4	-12	-12	-12	0	0
	5	+4.0	0	-12	0	0
	6	+6.4	0	-0.1	0	0
	7	-10	0	+12	0	0
	8	+12	+12	0	0	0
TRANSMIT MODE	1	+0.9	+4.3	-12	2.6	0
	2	+4.5	+0.5	-0.7	1.3	0.1
	3	+4.6	+0.52	-0.7	1.3	0.1
	4	-12	-12	-12	0	0
	5	+1.86	-2.67	-12	0	0
	6	+10.5	-2.67	+0.24	0	0.3
	7	-10	+6.5	+12	0	0
	8	+12	+12	0	0	0
		RESISTANCE (ohms)				
	1	13.24 kΩ	8.15 kΩ	2180		
	2	18.82 kΩ	2460	2490		
	3	8060	6000	6060		
	4	1220	1220	1220		
	5	13.27 kΩ	*75 kΩ	2180		
	6	*630 kΩ	*148 kΩ	8580		
	7	12.7 kΩ	4900	12.14 kΩ		
	8	12.16 kΩ	12.14 kΩ	NC		

*Measured on 200-kΩ range.
NC - No connection.

PIN LOCATION DIAGRAMS

2N2222A 2N3440	
FN2175	
ITS30482 (alternate for FN2175)	
MC1558 741	

A7A4 TRANSISTOR VOLTAGE AND RESISTANCE MEASUREMENTS

	LEAD	VOLTAGE (V dc)				
		Q1	Q2	Q3	Q4	Q5
RECEIVE MODE	E (S)	0	0	0	+0.05	0
	B (G)	+0.7	0	+0.63	+0.7	-4.33
	C (D)	+0.08	+28	+0.04	+3.34	+0.01
TRANSMIT MODE	E (S)	0	0	0	+79.9	0
	B (G)	0	+0.84	+0.26	+80	-2.7
	C (D)	+1.5	+0.25	+79.9	+80.2	+1.22
		RESISTANCE (ohms)				
	E (S)	0	0	0	13.79 kΩ	0
	B (G)	990	5670	5500	16.63 kΩ	6740
	C (D)	5800	*412 kΩ	13.78 kΩ	*376 kΩ	120

*Measured on 2000-kΩ range.

Figure FO-24. RF Filter Module A7, Schematic Diagram (Sheet 2 of 2)

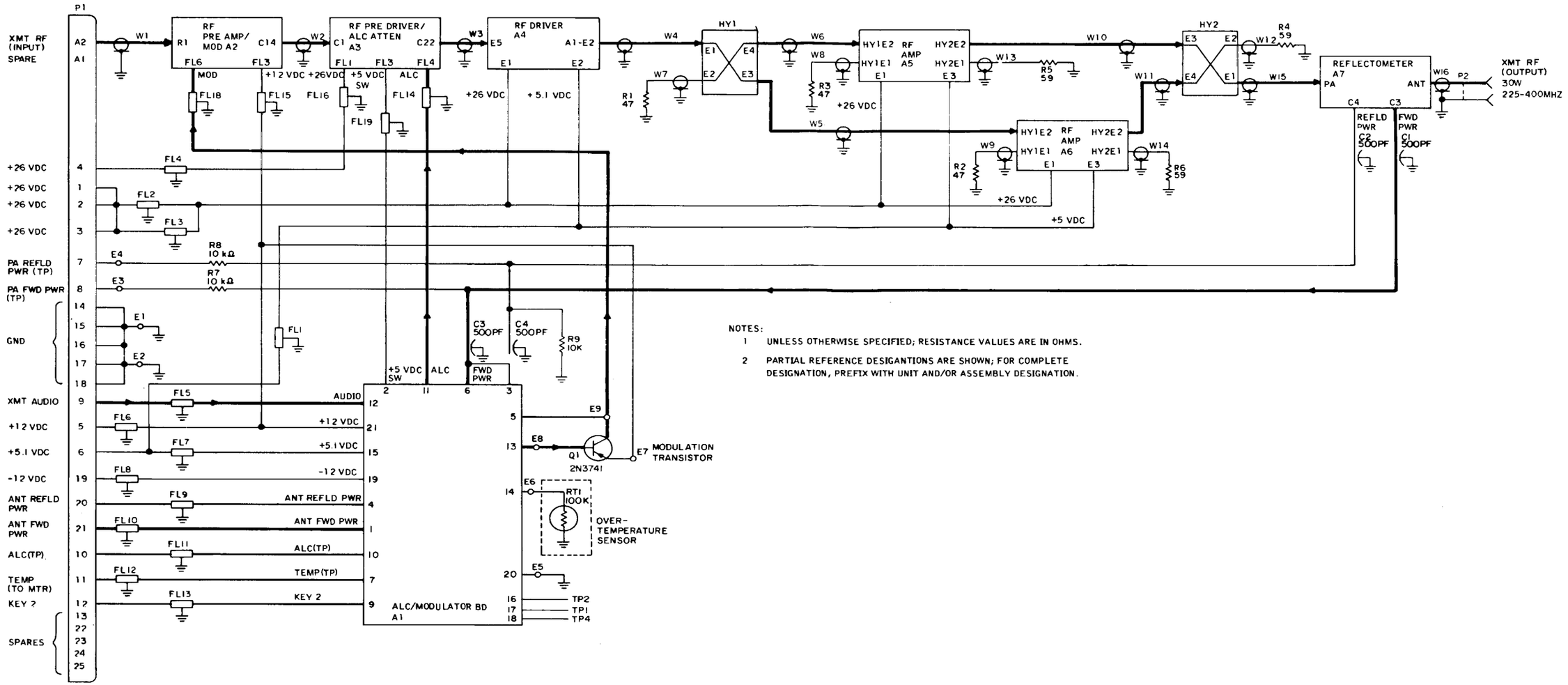


Figure FO-25. Power Amplifier Module A8, Schematic Diagram

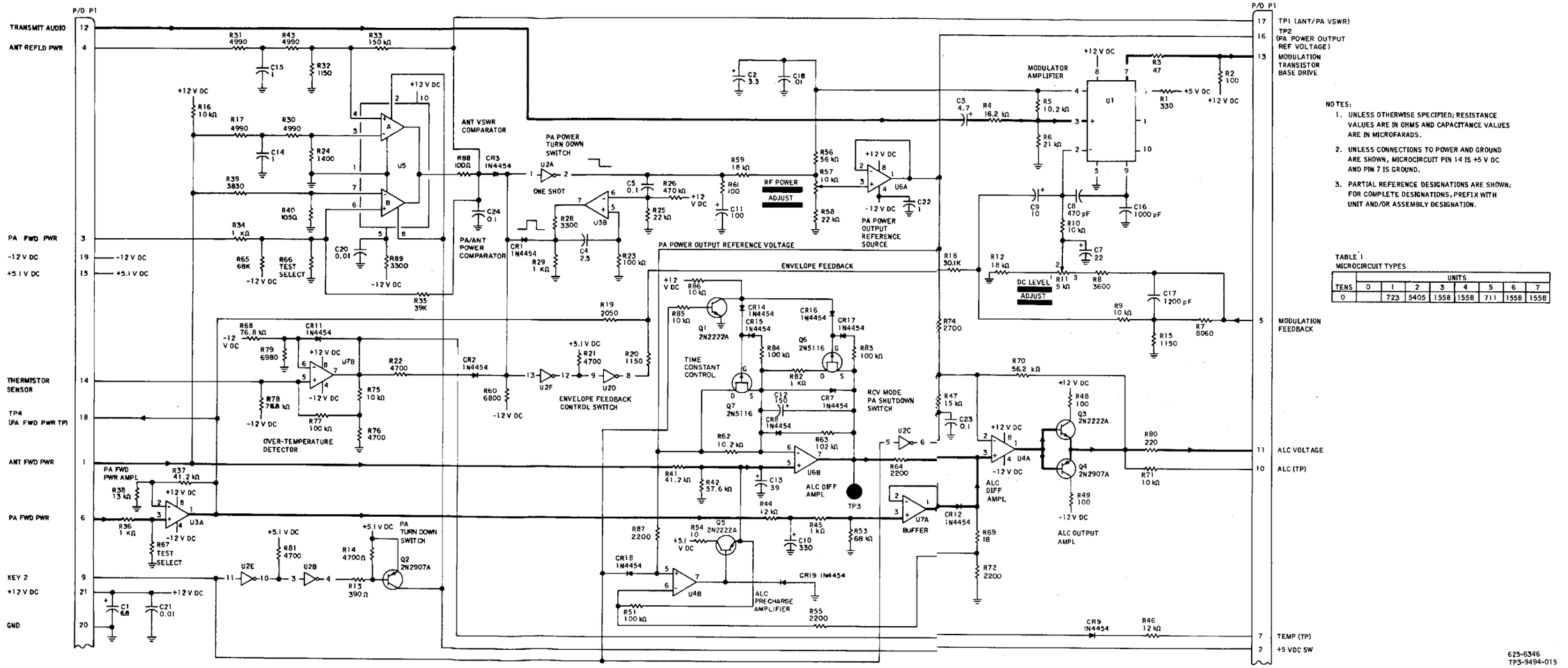


Figure FO-26. ALC/Modular A8A1, Schematic Diagram (Sheet 1 of 2)

VOLTAGE AND RESISTANCE MEASUREMENTS AND TEST CONDITIONS

Typical voltage measurements were obtained under the following conditions unless noted otherwise:

Dc measurements were taken with Fluke 8000A-01 Digital Multimeter. Ground reference point was GND test point on AN/GRC-171 front panel. Power amplifier module was extended to take voltage measurements.

Resistance measurements were taken with Fluke 8000A-01 Digital Multimeter. Unless otherwise noted, measurements were taken on 20-kΩ range. Power amplifier module was removed from chassis to take resistance measurements.

AN/GRC-171 Test Conditions

Input power: 120 V ac, 60 Hz

Receive mode

Front panel control settings

REMOTE/LOCAL switch	LOCAL
SQUELCH switch	OFF
PTT/CARRIER TEST switch	PTT
FREQUENCY switches	300.000 MHz

Transmit mode

CAUTION

To prevent possible damage to equipment resulting from loss of ALC voltage, decrease drive to power amplifier by installing a 10-dB pad in rf cable (transmit rf signal) from frequency synthesizer module to power amplifier module.

Install 10-dB pad in transmit rf cable between frequency synthesizer connector A2A6J1 and chassis cable connector A10A2P1.

Input audio signal at main audio input

Frequency	1000 Hz
Level	245 mV ac across 600 ohms (-10 dB mW)

Output connections

Antenna jack	Terminated into 50 ohms

Front panel control settings

REMOTE/LOCAL	LOCAL
SQUELCH	OFF
FREQUENCY	300.000 MHz
PTT/CARRIER TEST	CARRIER TEST
% MOD	90% modulation (front panel meter)

Voltages and resistances are not absolute and may vary between radio sets because of normal differences in component characteristics.

A8A1 TRANSISTOR VOLTAGE AND RESISTANCE MEASUREMENTS

	LEAD	VOLTAGE (V dc) Q1	Q2	Q3	Q4	Q5	Q6	Q7
RECEIVE MODE	E (S)	0	+5.03	-9.7	+9.7	+2.6	(+4.36)	(-2.36)
	B (G)	-0.65	+5.03	-9.7	+9.7	+2.8	(+4.16)	(-2.14)
	C (D)	-0.02	+0.12	+10.5	-12	+5.1	(+4.18)	(+2.18)
TRANSMIT MODE	E (S)	0	+4.94	-0.73	-0.73	+2.5	(+4.5)	(-2.18)
	B (G)	+0.09	+4.74	+1.3	+1.3	-0.8	(+11.7)	(+11.7)
	C (D)	+12	+4.1	+11.8	-12	+5	(+2.3)	(+2.3)
		RESISTANCE (ohms)						
	E (S)	0	2580	4700	4700	*28 kΩ	(4240)	(5100)
	B (G)	5780	7200	9200	9200	8300	(> 2 MΩ)	(> 2 MΩ)
	C (D)	14 kΩ	50	4200	5380	2500	(4310)	(5130)

*Measured on 200-kΩ range.

A8A1 TEST POINT VOLTAGE AND RESISTANCE MEASUREMENTS

TEST POINT	VOLTAGE (V dc) RCV MODE	XMT MODE	RESISTANCE (ohms)
1 (P1-17)	-0.5	-0.25	13 kΩ
2 (P1-16)	+2.18	+2.3	5130
3	+4.36	+4.5	4240
4 (P1-18)	-0.82	+2.2	8000

A8A1 INTEGRATED CIRCUIT VOLTAGE AND RESISTANCE MEASUREMENTS

	PIN	VOLTAGE (V dc) U1	U2	U3	U4	U5	U6	U7
RECEIVE MODE	1	0	+0.66	-0.82	-9.7	0	+2.18	-6.85
	2	+4.8	+2.6	-0.2	[a]	+0.12	+2.18	-6.85
	3	+4.8	+0.05	-0.2	-2.19	-0.005	[a]	-6.85
	4	+7.1	+5	-12	-12	-0.016	-12	-12
	5	0	+4.36	0	+2.18	-4.26	-2.6	**-5.09
	6	+7.3	+0.04	+0.53	+2.18	-0.36	+2.36	**-5.12
	7	+11.2	0	-9.9	-2.8	-0.08	+4.36	**-5.71
	8	+12	+0.05	12	12	0.12	+12	+12
	9	+8.3	+5	NC	NC	-0.516	NC	NC
	10	0	+0.05	NC	NC	+12	NC	NC
	11	NC	+4.36	NC	NC	NC	NC	NC
	12	NC	+5	NC	NC	NC	NC	NC
	13	NC	+0.66	NC	NC	NC	NC	NC
	14	NC	+5	NC	NC	NC	NC	NC
TRANSMIT MODE	1	0	+0.54	+2.2	1.3	0	+2.3	+1.9
	2	+4.8	+2.6	+0.75	[a]	+4.1	+2.3	+1.9
	3	+4.8	+5	+0.74	2.3	+0.52	[a]	+1.7
	4	+7.1	+0.1	-12	-12	+0.05	-12	-12
	5	0	+0.04	0	-0.7	-5.5	+2.5	**-4.5
	6	+7.3	+2.3	+0.53	-2.1	-0.24	+2.18	**-4.5
	7	+11	0	-9.9	-0.8	+0.876	+4.5	**-5.1
	8	+12	+0.05	+12	-12	+4.1	+12	+12
	9	+8.6	+5	NC	NC	-0.25	NC	NC
	10	0	+5	NC	NC	+12	NC	NC
	11	NC	+0.04	NC	NC	NC	NC	NC
	12	NC	+5	NC	NC	NC	NC	NC
	13	NC	+0.54	NC	NC	NC	NC	NC
	14	NC	+5	NC	NC	NC	NC	NC
		RESISTANCE (ohms)						
	1	> 2 MΩ	12 kΩ	8000	9200	0	5130	6500
	2	12 kΩ	*43 kΩ	11 kΩ	7470	50	5130	6500
	3	12 kΩ	7200	2290	2200	1270	*25 kΩ	17 kΩ
	4	8860	7650	5380	5380	1140	5380	5380
	5	0	16 kΩ	*100 kΩ	7240	4300	*28 kΩ	*37 kΩ
	6	2900	18 kΩ	22 kΩ	4240	2240	5100	5790
	7	4320	0	4210	8300	980	4240	7850
	8	4180	9270	4180	4180	50	4180	4180
	9	8100	7140	NC	NC	13 kΩ	NC	NC
	10	12 kΩ	7200	NC	NC	4180	NC	NC
	11	NC	16 kΩ	NC	NC	NC	NC	NC
	12	NC	7140	NC	NC	NC	NC	NC
	13	NC	12 kΩ	NC	NC	NC	NC	NC
	14	NC	2580	NC	NC	NC	NC	NC

*Measured on 200-kΩ range.
**Varies with temperature of heat sink.
[a]Do not measure.

PIN LOCATION DIAGRAMS

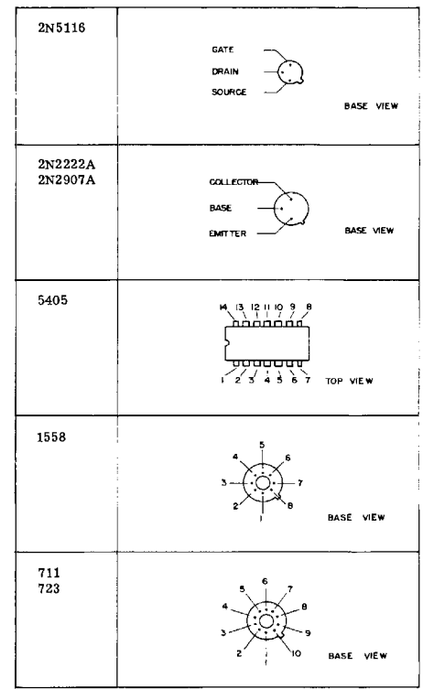


Figure FO-26. ALC/Modulator A8A1, Schematic Diagram (Sheet 2 of 2)

VOLTAGE AND RESISTANCE MEASUREMENTS AND TEST CONDITIONS

Typical voltage measurements were obtained under the following conditions unless noted otherwise:

Dc measurements were taken with Fluke 8000A-01 Digital Multimeter. Ground reference point was GND test point on AN/GRC-171 front panel. Power amplifier module was extended to take voltage measurements.

Resistance measurements were taken with Fluke 8000A-01 Digital Multimeter. Unless otherwise noted, measurements were taken on 20-kΩ range. Power amplifier module was removed from chassis to take resistance measurements.

AN/GRC-171 Test Conditions

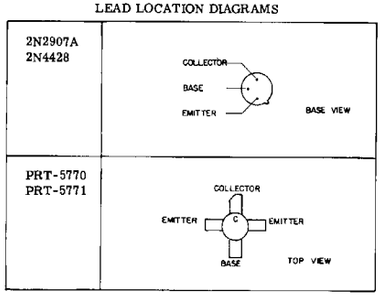
Input power: 120 V ac, 60 Hz

Transmit mode

Input audio signal at main audio input	
Frequency	1000 Hz
Level	245 mV ac across 600 ohms (-10 dB mW)
Output connections	
Antenna jack	Terminated into 50 ohms
Front panel control settings	
REMOTE/LOCAL	LOCAL
SQUELCH	OFF
FREQUENCY	300.000 MHz
PTT/CARRIER TEST	CARRIER TEST
% MOD	90% modulation (front panel matter)

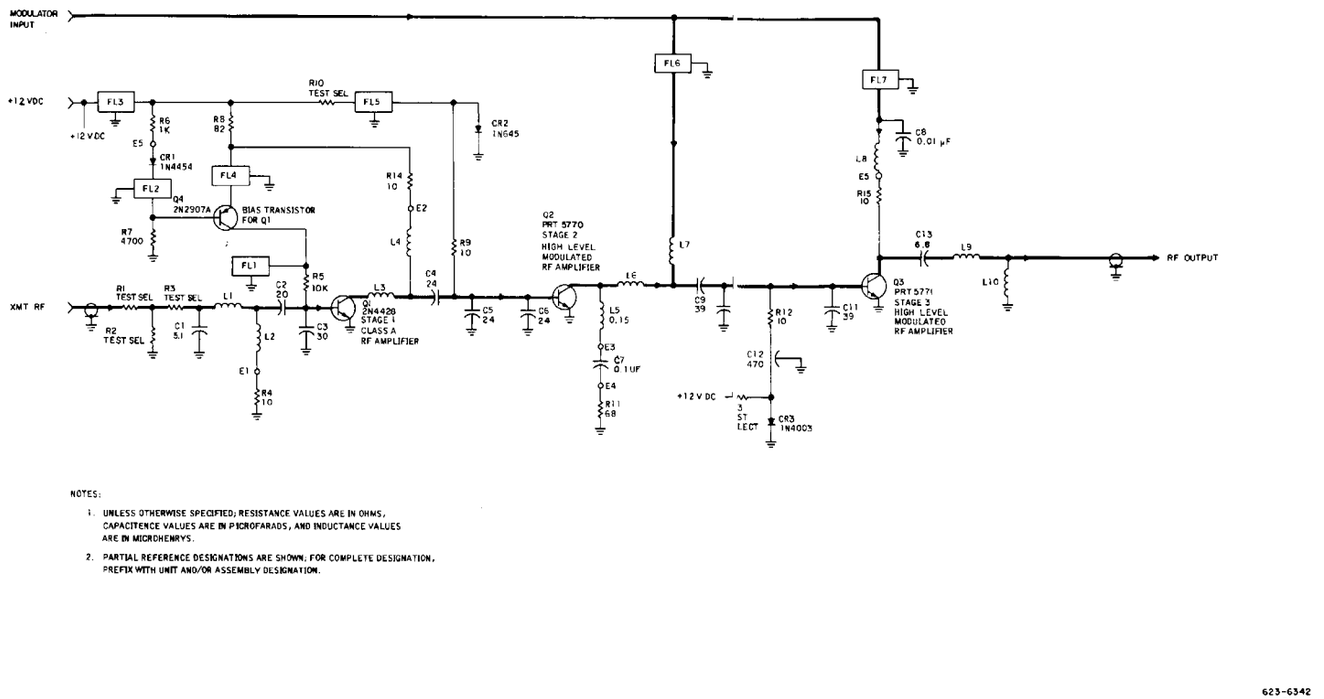
Voltages and resistances are not absolute and may vary between radio sets because of normal differences in component characteristics.

LEAD LOCATION DIAGRAMS



A8A2 VOLTAGE AND RESISTANCE MEASUREMENTS

LEAD	VOLTAGE (V dc)			
	Q1	Q2	Q3	Q4
E	0	0	0	+9.8
B	+0.7	+0.7	+0.7	+9.2
C	+9.6	+6	+6	+4.1
RESISTANCE (ohms)				
E	4600	0	0	0
B	4600	6300	4700	4400
C	6800	4600	5600	5900



NOTES:

1. UNLESS OTHERWISE SPECIFIED, RESISTANCE VALUES ARE IN OHMS, CAPACITANCE VALUES ARE IN PICROFARADS, AND INDUCTANCE VALUES ARE IN MICROHENRYS.
2. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN; FOR COMPLETE DESIGNATION, PREFIX WITH UNIT AND/OR ASSEMBLY DESIGNATION.

623-6342
TP3-7651-014

Figure FO-27 . RF Preamplifier/Modulator A8A2, Schematic Diagram

VOLTAGE AND RESISTANCE MEASUREMENTS AND TEST CONDITIONS

Typical voltage measurements were obtained under the following conditions unless noted otherwise:

Dc measurements were taken with Fluke 8000A-01 Digital Multimeter. Ground reference point was GND test point on AN/GRC-171 front panel. Power amplifier module was extended to take voltage measurements.

Resistance measurements were taken with Fluke 8000A-01 Digital Multimeter. Unless otherwise noted, measurements were taken on 20-kΩ range. Power amplifier module was removed from chassis to take resistance measurements.

AN/GRC-171 Test Conditions

Input power: 120 V ac, 60 Hz

Transmit mode

CAUTION

To prevent possible damage to equipment resulting from loss of ALC voltage, decrease drive to power amplifier by installing a 10-dB pad in rf cable (transmit rf signal) from frequency synthesizer module to power amplifier module.

Install 10-dB pad in transmit rf cable between frequency synthesizer connector A2A6J1 and chassis cable connector A10A2P1.

Input audio signal at main audio input	
Frequency	1000 Hz
Level	245 mV ac across 600 ohms (-10 dB mW)
Output connections	
Antenna jack	Terminated into 50 ohms
Front panel control settings	
REMOTE/LOCAL	LOCAL
SQUELCH	OFF
FREQUENCY	300.000 MHz
PTT/CARRIER TEST	CARRIER TEST
% MOD	90% modulation (front panel meter)

Voltages and resistances are not absolute and may vary between radio sets because of normal differences in component characteristics.

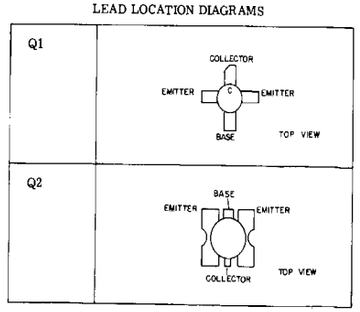
A8A3 DIODE VOLTAGE AND RESISTANCE MEASUREMENTS

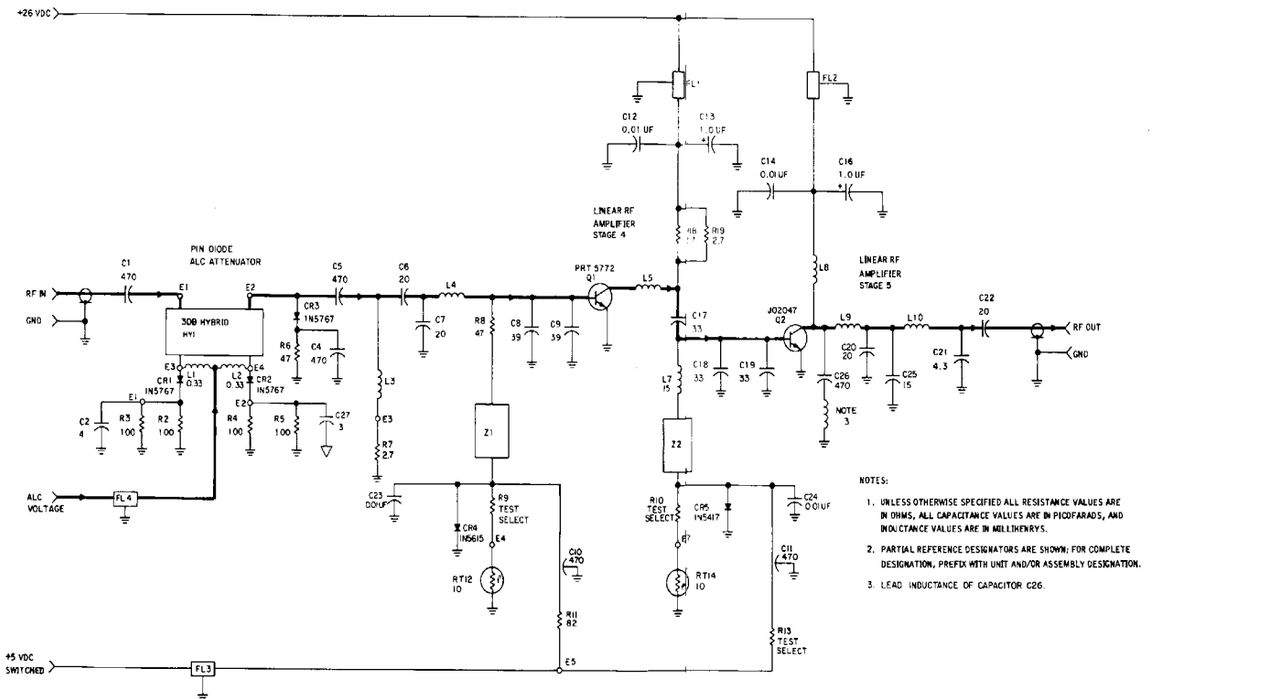
	LEAD	VOLTAGE (V dc)				
		CR1	CR2	CR3	CR4	CR5
RECEIVE MODE	A	-1.4	+1.4	+1.4	+0.07	+0.07
	C	+0.6	+0.6	+0.6	0	0
TRANSMIT MODE	A	+0.4	+0.4	+0.4	+0.57	+0.5
	C	+0.02	+0.02	+0.02	0	0
		RESISTANCE (ohms)				
	A	4800	4800	4800	21	13
	C	50	50	50	0	0

A8A3 TRANSISTOR VOLTAGE AND RESISTANCE MEASUREMENTS

	LEAD	VOLTAGE (V dc)	
		Q1	Q2
RECEIVE MODE	E	0	0
	B	+0.07	+0.07
	C	+26	+26
TRANSMIT MODE	E	0	0
	B	+0.57	+0.50
	C	+26	+26
		RESISTANCE (ohms)	
	E	0	0
	B	68	13
	C	> 2 MΩ	> 2 MΩ

LEAD LOCATION DIAGRAMS




+26 VDC
RF IN
GND
ALC VOLTAGE
+5 VDC SWITCHED
PIN DIODE ALC ATTENUATOR
30dB HYBRID HY1
LINEAR RF AMPLIFIER STAGE 4
LINEAR RF AMPLIFIER STAGE 5
PRT 5772 Q1
JO2047 Q2
RF OUT
GND
NOTES:
1. UNLESS OTHERWISE SPECIFIED ALL RESISTANCE VALUES ARE IN OHMS, ALL CAPACITANCE VALUES ARE IN PICOFARADS, AND INDUCTANCE VALUES ARE IN MILLIHENRYS.
2. PARTIAL REFERENCE DESIGNATORS ARE SHOWN; FOR COMPLETE DESIGNATION, PREFIX WITH UNIT AND/OR ASSEMBLY DESIGNATION.
3. LEAD INDUCTANCE OF CAPACITOR C26.

623-6341
TP3-7650-014

Figure FO-28 . RF Predriver/ALC Attenuator A8A3, Schematic Diagram

VOLTAGE AND RESISTANCE MEASUREMENTS AND TEST CONDITIONS

Typical voltage measurements were obtained under the following conditions unless noted otherwise:

Dc measurements were taken with Fluke 8000A-01 Digital Multimeter. Ground reference point was GND test point on AN/GRC-171 front panel. Power amplifier module was extended to take voltage measurements.

Resistance measurements were taken with Fluke 8000A-01 Digital Multimeter. Unless otherwise noted, measurements were taken on 20-kΩ range. Power amplifier module was removed from chassis to take resistance measurements.

AN/GRC-171 Test Conditions

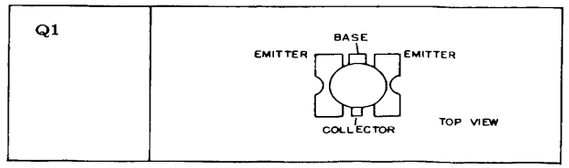
Input power: 120 V ac, 60 Hz

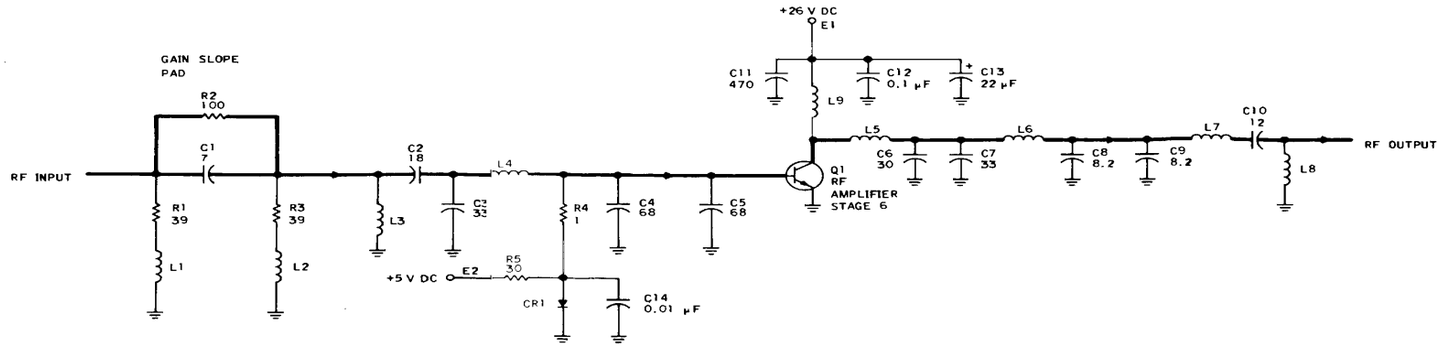
Transmit mode

Input audio signal at main audio input	
Frequency	1000 Hz
Level	245 mV ac across 600 ohms (-10 dB mW)
Output connections	
Antenna jack	Terminated into 50 ohms
Front panel control settings	
REMOTE/LOCAL	LOCAL
SQUELCH	OFF
FREQUENCY	300.000 MHz
PTT/CARRIER TEST	CARRIER TEST
% MOD	90% modulation (front panel meter)

Voltages and resistances are not absolute and may vary between radio sets because of normal differences in component characteristics.

LEAD LOCATION DIAGRAM





NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL RESISTANCE VALUES ARE IN OHMS AND ALL CAPACITANCE VALUES ARE IN PICOFARADS.
2. PARTIAL REFERENCE DESIGNATORS ARE SHOWN; FOR COMPLETE DESIGNATION, PREFIX WITH MODULE AND ASSEMBLY DESIGNATION.

A8A4 TRANSISTOR VOLTAGE AND RESISTANCE MEASUREMENTS

LEAD	VOLTAGE (V dc)
	Q1
E	0
B	+0.7
C	+26
	RESISTANCE (ohms)
E	0
B	3040
C	*880

*Measured on 2-kΩ range.

Figure FO-29 . RF Driver A8A4, Schematic Diagram

VOLTAGE AND RESISTANCE MEASUREMENTS AND TEST CONDITIONS

Typical voltage measurements were obtained under the following conditions unless noted otherwise:

Dc measurements were taken with Fluke 8000A-01 Digital Multimeter. Ground reference point was GND test point on AN/GRC-171 front panel. Power amplifier module was extended to take voltage measurements.

Resistance measurements were taken with Fluke 8000A-01 Digital Multimeter. Unless otherwise noted, measurements were taken on 20-kΩ range. Power amplifier module was removed from chassis to take resistance measurements.

AN/GRC-171 Test Conditions

Input power: 120 V ac, 60 Hz

Transmit mode

Input audio signal at main audio input

Frequency	1000 Hz
Level	245 mV ac across 600 ohms (-10 dB mW)

Output connections

Antenna jack	Terminated into 50 ohms

Front panel control settings

REMOTE/LOCAL	LOCAL
SQUELCH	OFF
FREQUENCY	300.000 MHz
PTT/CARRIER TEST	CARRIER TEST
% MOD	90% modulation (front panel meter)

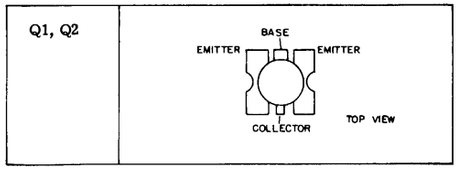
Voltages and resistances are not absolute and may vary between radio sets because of normal differences in component characteristics.

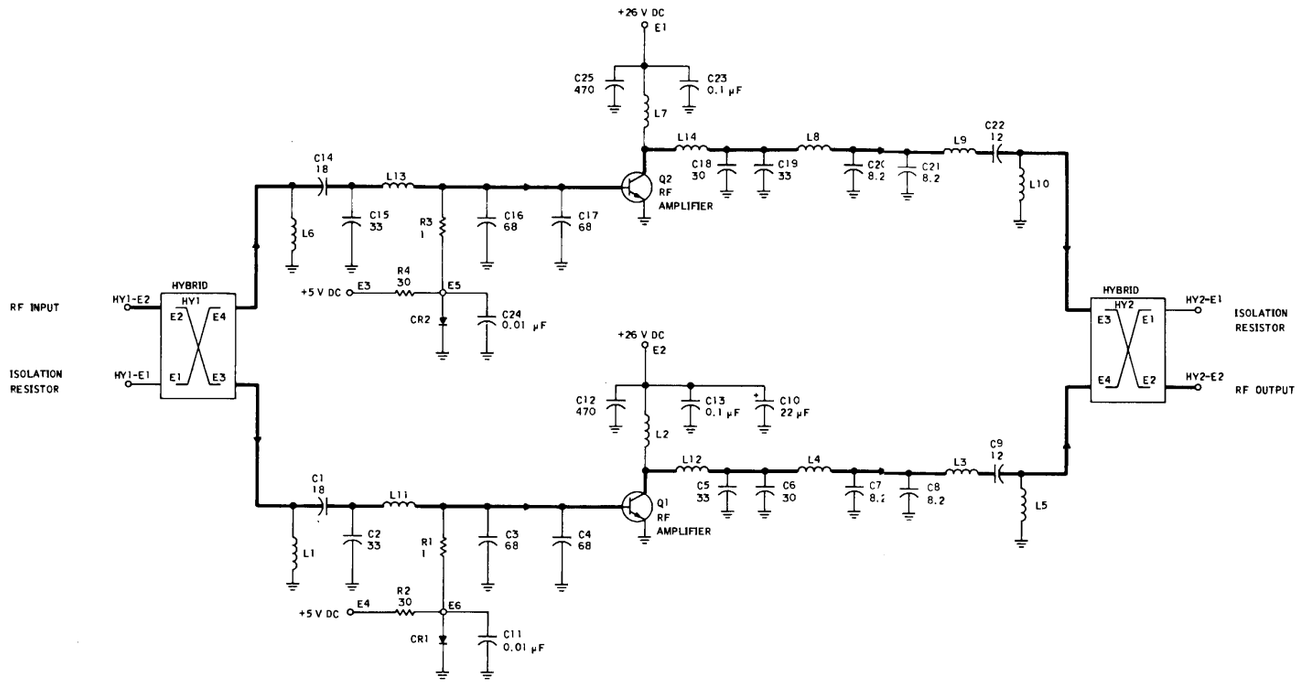
A8A5/A6 TRANSISTOR VOLTAGE AND RESISTANCE MEASUREMENTS

LEAD	VOLTAGE (V dc)	
	Q1	Q2
E	0	0
B	+0.7	+0.7
C	+26	+26
RESISTANCE (ohms)		
E	0	0
B	3040	3040
C	*880	*880

*Measured on 2-kΩ range.

LEAD LOCATION DIAGRAM





NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL RESISTANCE VALUES ARE IN OHMS AND ALL CAPACITANCE VALUES ARE IN PICOFARADS.
2. PARTIAL REFERENCE DESIGNATORS ARE SHOWN; FOR COMPLETE DESIGNATION, PREFIX WITH MODULE AND ASSEMBLY DESIGNATION.

Figure FO-30 . RF Amplifier A8A5/A6, Schematic Diagram

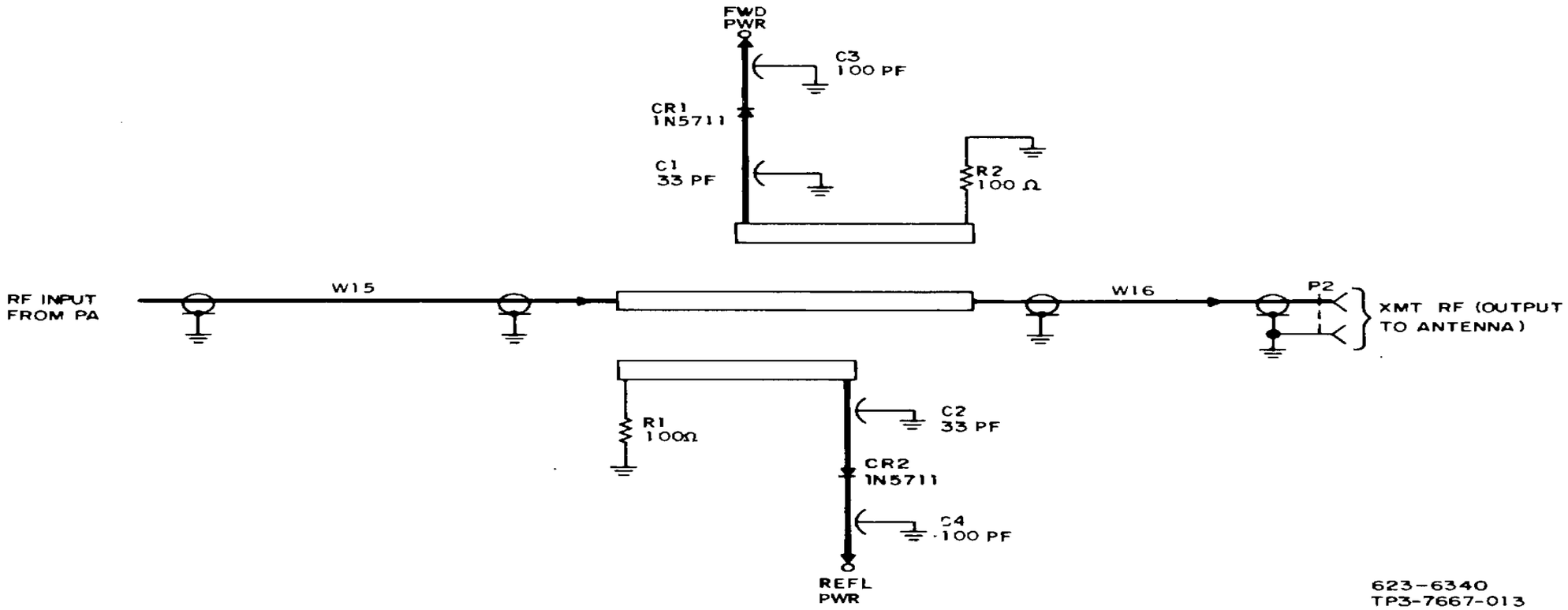


Figure FO-31 . Reflectometer A8A7, Schematic Diagram

VOLTAGE AND RESISTANCE MEASUREMENTS AND TEST CONDITIONS

Typical voltage measurements were obtained under the following conditions unless noted otherwise:

Dc measurements were taken with Fluke 8000A-01 Digital Multimeter. Ground reference point was GND test point on AN/GRC-171 front panel. Module was extended to take voltage measurements.

Resistance measurements were taken with Fluke 8000A-01 Digital Multimeter. Unless otherwise noted, measurements were taken on 20-kΩ range with module ground test point as ground reference. Module was removed from chassis to take resistance measurements.

AN/GRC-171 Test Conditions

Input power: 120 V ac, 60 Hz

Receive mode

Front panel control settings

REMOTE/LOCAL switch	LOCAL
SQUELCH switch	OFF
PTT/CARRIER TEST switch	PTT

Voltages and resistances are not absolute and may vary between radio sets because of normal differences in component characteristics.

A9 TRANSISTOR VOLTAGE/ RESISTANCE MEASUREMENTS (RCV MODE)

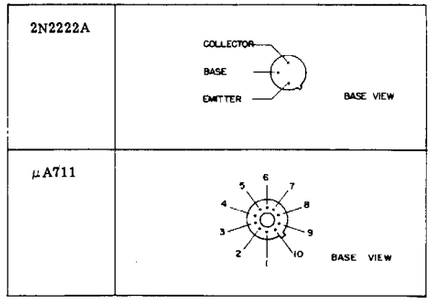
LEAD	VOLTAGE (V dc)	
	Q1	Q2
E	+0.65	0
B	+1.3	0
C	+0.7	0
RESISTANCE (ohms)		
E	5400	0
B	11 kΩ	6000
C	360 kΩ	> 2 MΩ

A9 INTEGRATED CIRCUIT VOLTAGE AND RESISTANCE MEASUREMENTS

PIN	VOLTAGE (V dc)		RESISTANCE (ohms)	
	U1	U2	U1	U2
1	0	0	0	0
2	0	+0.04	5400	3500
3	-0.26	+0.12	220	3500
4	-5.2	-5.2	14 kΩ	14 kΩ
5	NC	NC	NC	NC
6	NC	NC	NC	NC
7	+3	-0.5	12 kΩ	16 kΩ
8	+12	+12	360 kΩ	360 kΩ

NC - No connection.

PIN LOCATION DIAGRAMS



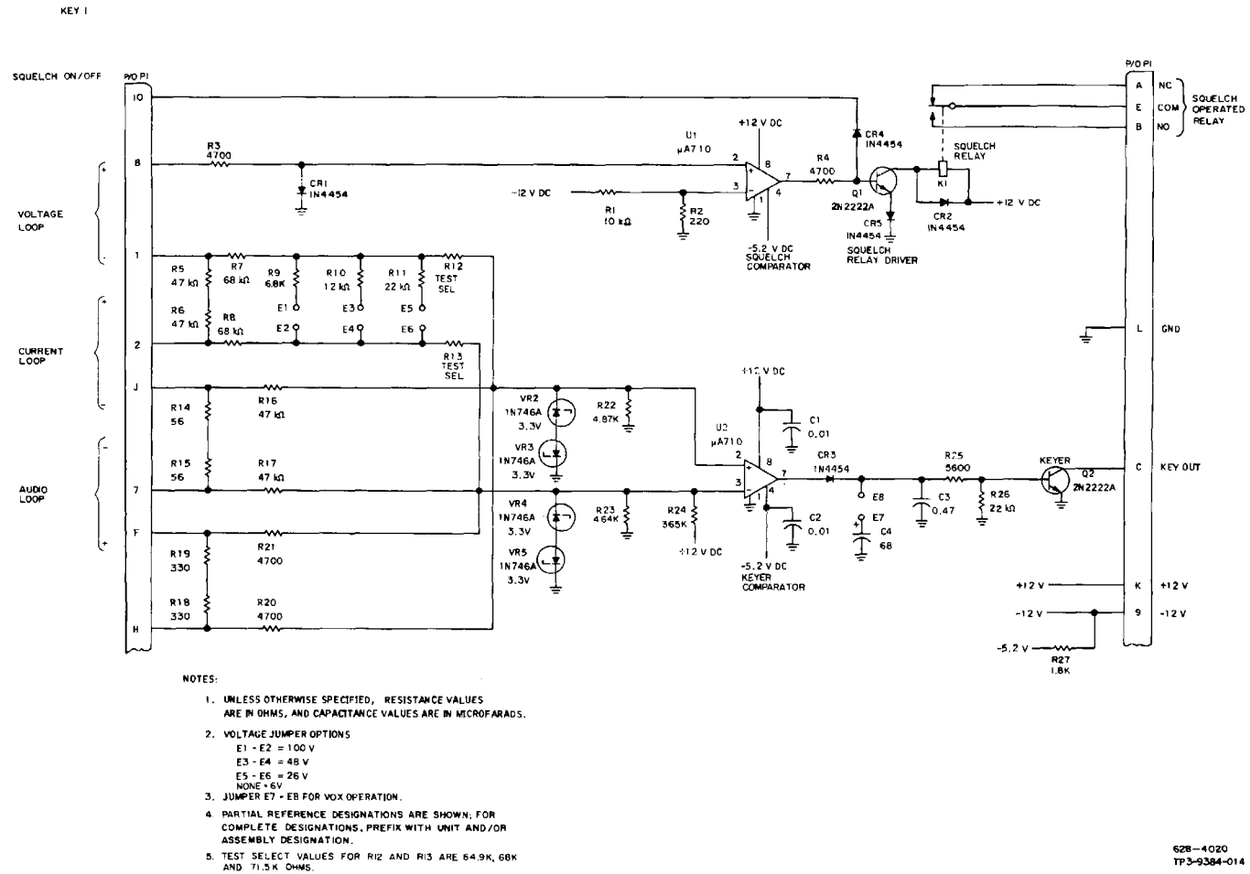

KEY I
SQUELCH ON/OFF
P/O P1
VOLTAGE LOOP
CURRENT LOOP
AUDIO LOOP
+12 V DC
-12 V DC
-5.2 V DC SQUELCH COMPARATOR
SQUELCH RELAY DRIVER
SQUELCH RELAY
SQUELCH OPERATED RELAY
-5.2 V DC KEYER COMPARATOR
KEYER
KEY OUT
GND
+12 V
-12 V
-5.2 V
TEST SEL
NOTES:
1. UNLESS OTHERWISE SPECIFIED, RESISTANCE VALUES ARE IN OHMS, AND CAPACITANCE VALUES ARE IN MICROFARADS.
2. VOLTAGE JUMPER OPTIONS
E1 - E2 = 100 V
E3 - E4 = 48 V
E5 - E6 = 26 V
NONE = 6V
3. JUMPER E7 - E8 FOR VOX OPERATION.
4. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN; FOR COMPLETE DESIGNATIONS, PREFIX WITH UNIT AND/OR ASSEMBLY DESIGNATION.
5. TEST SELECT VALUES FOR R12 AND R13 ARE 64.9K, 68K AND 71.5K OHMS.
628-4020
TP3-9384-014

Figure FO-32 . Keyer Module A9, Schematic Diagram

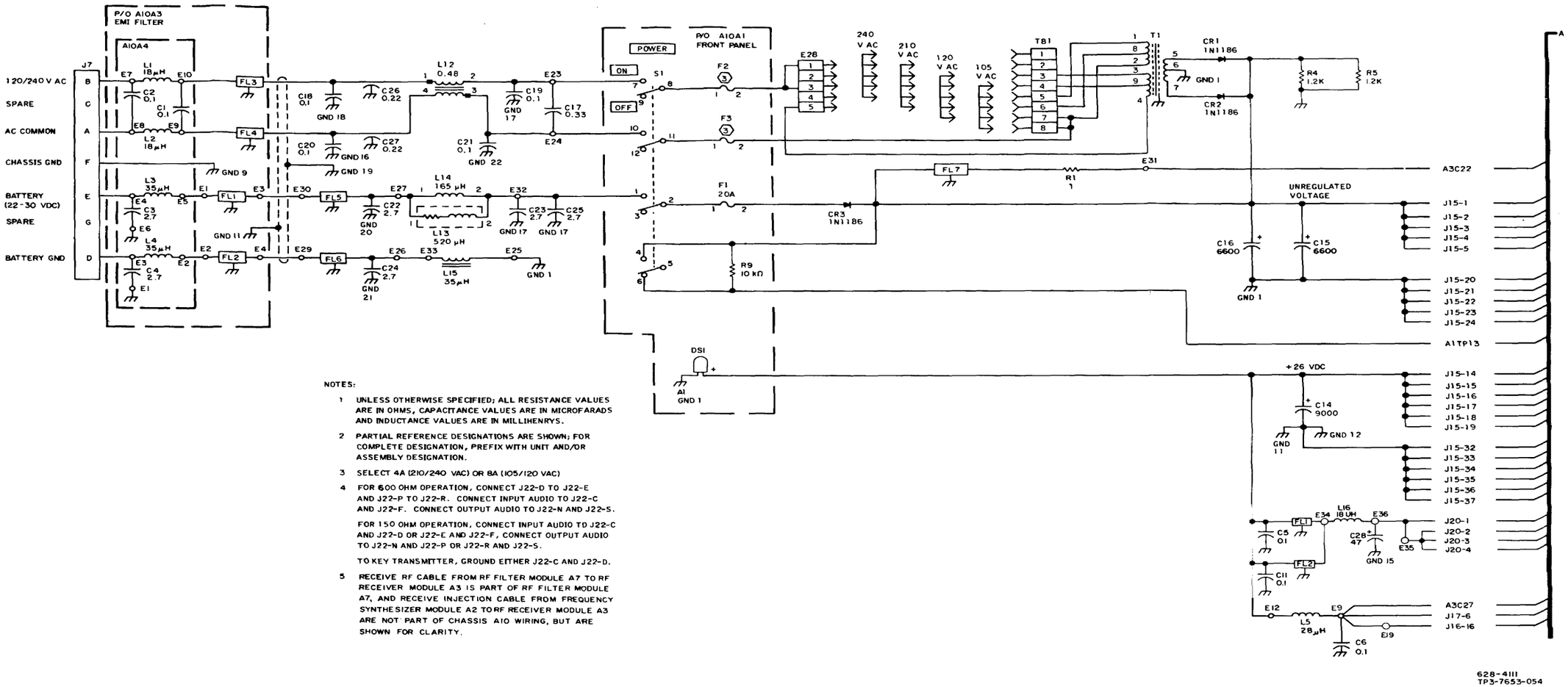

P/O A10A3
EMI FILTER
A10A4
P/O A10A1
FRONT PANEL
POWER
ON
OFF
120/240 V AC
SPARE
AC COMMON
CHASSIS GND
BATTERY
(22-30 VDC)
SPARE
BATTERY GND
240 V AC
210 V AC
120 V AC
105 V AC
UNREGULATED
VOLTAGE
+26 VDC
A3C22
A1TP13
A3C27
J17-6
J16-16
GND 1
GND 9
GND 11
GND 12
GND 15
GND 16
GND 17
GND 18
GND 19
GND 20
GND 21
GND 22
DS1
A1
NOTES:
1 UNLESS OTHERWISE SPECIFIED; ALL RESISTANCE VALUES ARE IN OHMS, CAPACITANCE VALUES ARE IN MICROFARADS AND INDUCTANCE VALUES ARE IN MILLIHENRYS.
2 PARTIAL REFERENCE DESIGNATIONS ARE SHOWN; FOR COMPLETE DESIGNATION, PREFIX WITH UNIT AND/OR ASSEMBLY DESIGNATION.
3 SELECT 4A (210/240 VAC) OR 8A (105/120 VAC)
4 FOR 600 OHM OPERATION, CONNECT J22-D TO J22-E AND J22-P TO J22-R. CONNECT INPUT AUDIO TO J22-C AND J22-F. CONNECT OUTPUT AUDIO TO J22-N AND J22-S.
FOR 150 OHM OPERATION, CONNECT INPUT AUDIO TO J22-C AND J22-D OR J22-E AND J22-F, CONNECT OUTPUT AUDIO TO J22-N AND J22-P OR J22-R AND J22-S.
TO KEY TRANSMITTER, GROUND EITHER J22-C AND J22-D.
5 RECEIVE RF CABLE FROM RF FILTER MODULE A7 TO RF RECEIVER MODULE A3 IS PART OF RF FILTER MODULE A7, AND RECEIVE INJECTION CABLE FROM FREQUENCY SYNTHESIZER MODULE A2 TO RF RECEIVER MODULE A3 ARE NOT PART OF CHASSIS A10 WIRING, BUT ARE SHOWN FOR CLARITY.
628-4111
TP3-7653-054

Figure FO-33. Chassis A10, Schematic Diagram
(Sheet 1 of 5)

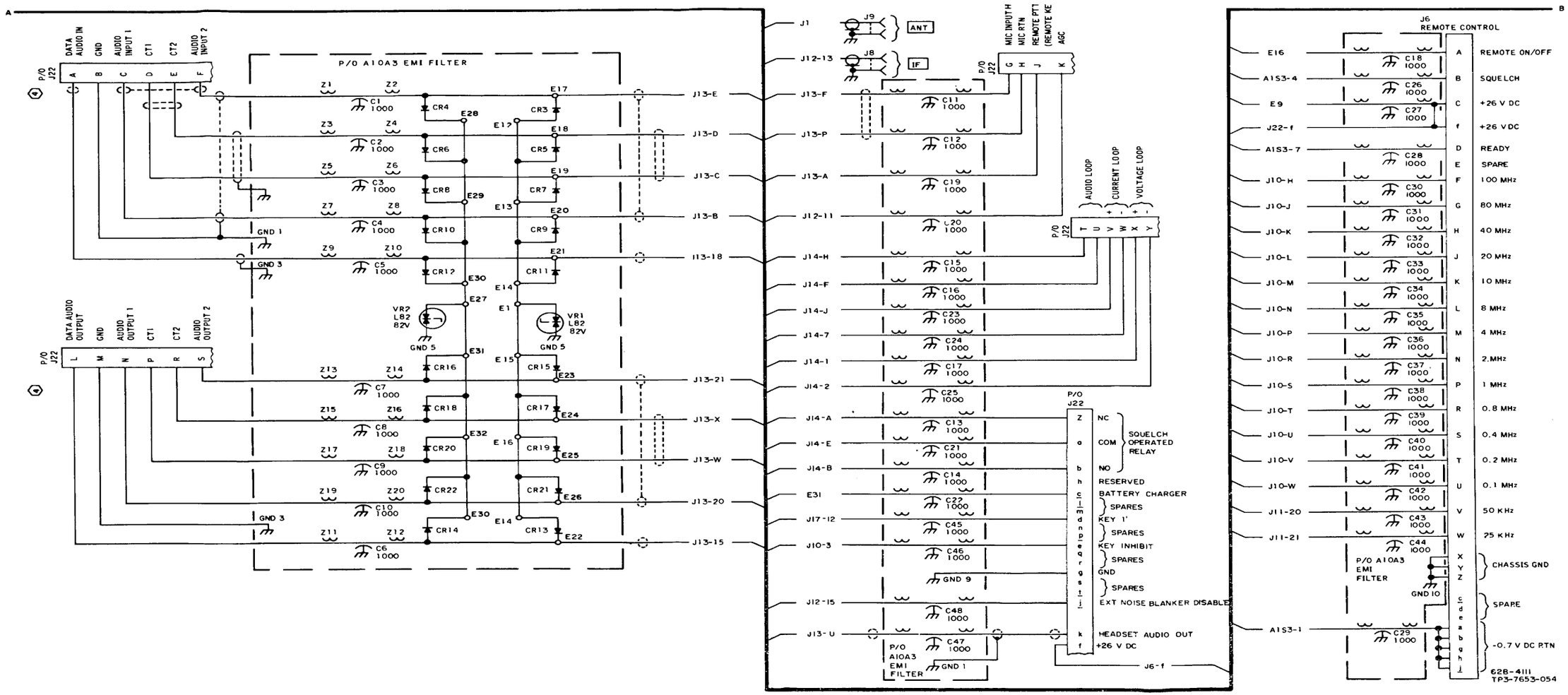


Figure FO-33. Chassis A10, Schematic Diagram
(Sheet 2 of 5)

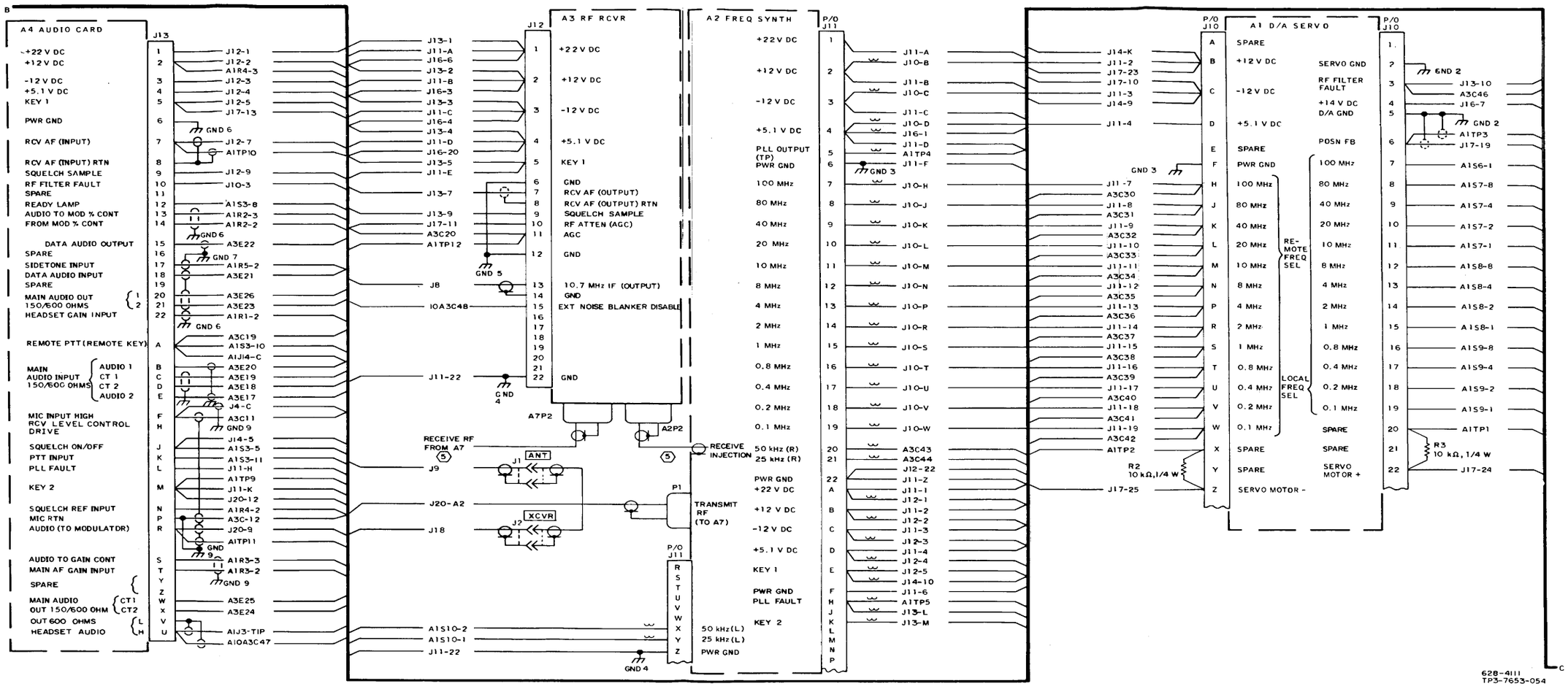


Figure FO-33. Chassis A10, Schematic Diagram
(Sheet 3 of 5)

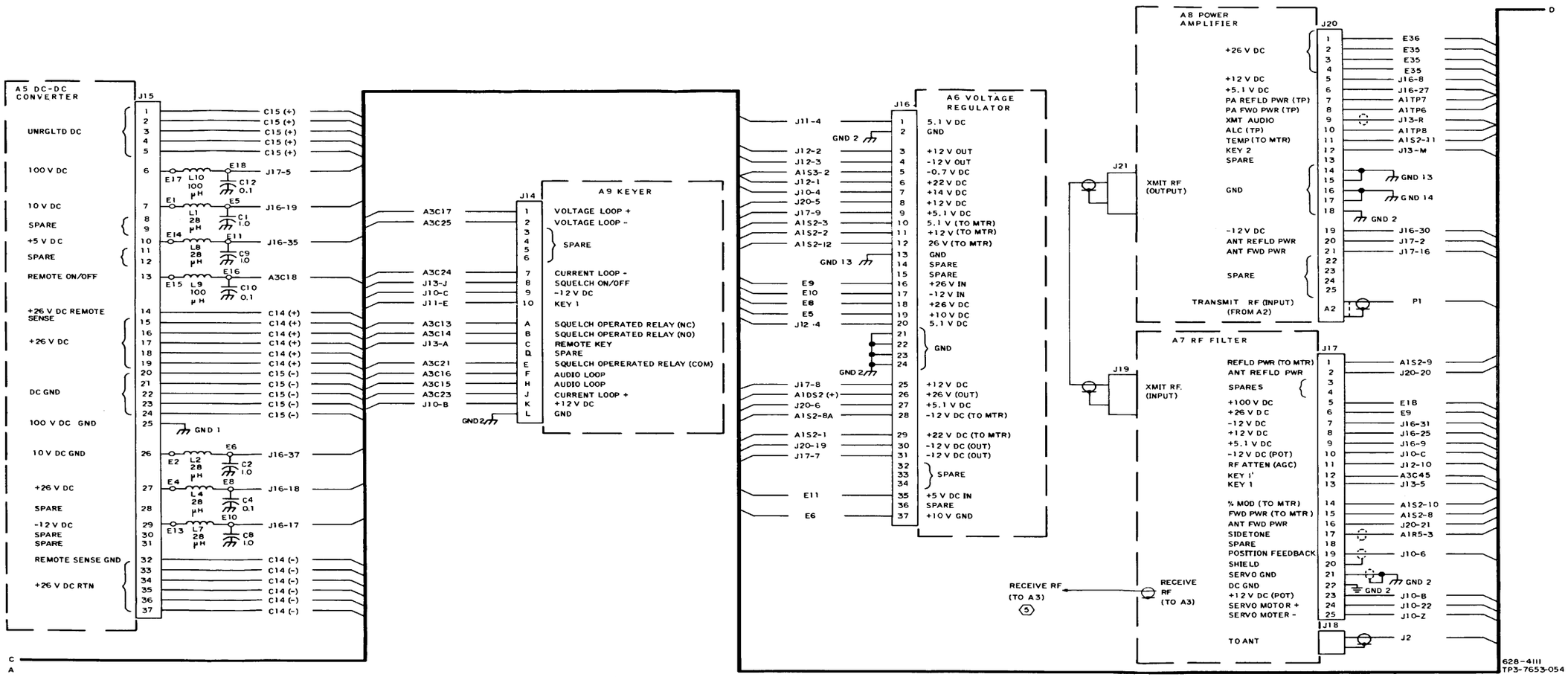


Figure FO-33. Chassis A10, Schematic Diagram
(Sheet 4 of 5)

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VOLTAGE AND RESISTANCE MEASUREMENTS AND TEST CONDITIONS

Typical voltage measurements were obtained under the following conditions unless noted otherwise:

Ac and dc measurements were taken with Fluke 8000A-01 Digital Multimeter. Ground reference point was GND test point on AN/GRC-171 front panel. Modules were extended to take voltage measurements.

AN/GRC-171 Test Conditions

Input power: 120 V ac, 60 Hz

Receive mode

Input rf signal at antenna	
Frequency	300.000 MHz
Level	1 mV
Modulation	1000 Hz, 30%
Output connections	
Main audio output	Terminated into 600 ohms
Headset jack	Terminated into 600 ohms
Front panel control settings	
REMOTE/LOCAL switch	LOCAL
SQUELCH switch	OFF
PTT/CARRIER TEST switch	PTT
FREQUENCY switches	300.000 MHz
RCV AUDIO control	100 mW into 600 ohms at main audio output
VOL control	1 mW into 600 ohms at headset jack

Transmit mode

Input audio signal at main audio input	
Frequency	1000 Hz
Level	245 mV ac across 600 ohms (-10 dB mW)
Output connections	
Antenna jack	Terminated into 50 ohms
Main audio output	Terminated into 600 ohms
Front panel control settings	
REMOTE/LOCAL	LOCAL
SQUELCH	OFF
FREQUENCY	300.000 MHz
PTT/CARRIER TEST	CARRIER TEST
% MOD	90% modulation (front panel meter)
SIDETONE	100 mW into 600 ohms at main audio output

Voltages are not absolute and may vary between radio sets because of normal differences in component characteristics.

TEST POINT VOLTAGE

TEST POINT	SIGNAL	RECEIVE MODE	TRANSMIT MODE
1	SERVO +	0 to +6.5 V dc	0 to +6.5 V dc
2	SERVO -	0 to +6.5 V dc	0 to +6.5 V dc
3	TUNE VOLT	-560 mV dc	-560 mV dc
4	PLL OUT	+640 mV dc	+360 mV dc
5	PLL FAULT	+4.46 V dc	+4.3 V dc
6	PA FWD PWR	0	+710 mV dc
7	PA REFLD PWR	0	+75 mV dc
8	ALC	+9.7 V dc	760 mV dc
9	KEY	+4.3 V dc	70 mV dc
10	RCV AUDIO	240 mV ac	0
11	XMT AUDIO	0	950 mV ac
12	IF AGC	-1.96 V dc	+440 mV dc
13	RECT DC	+50 V dc	+46 V dc
14	GND	0	0

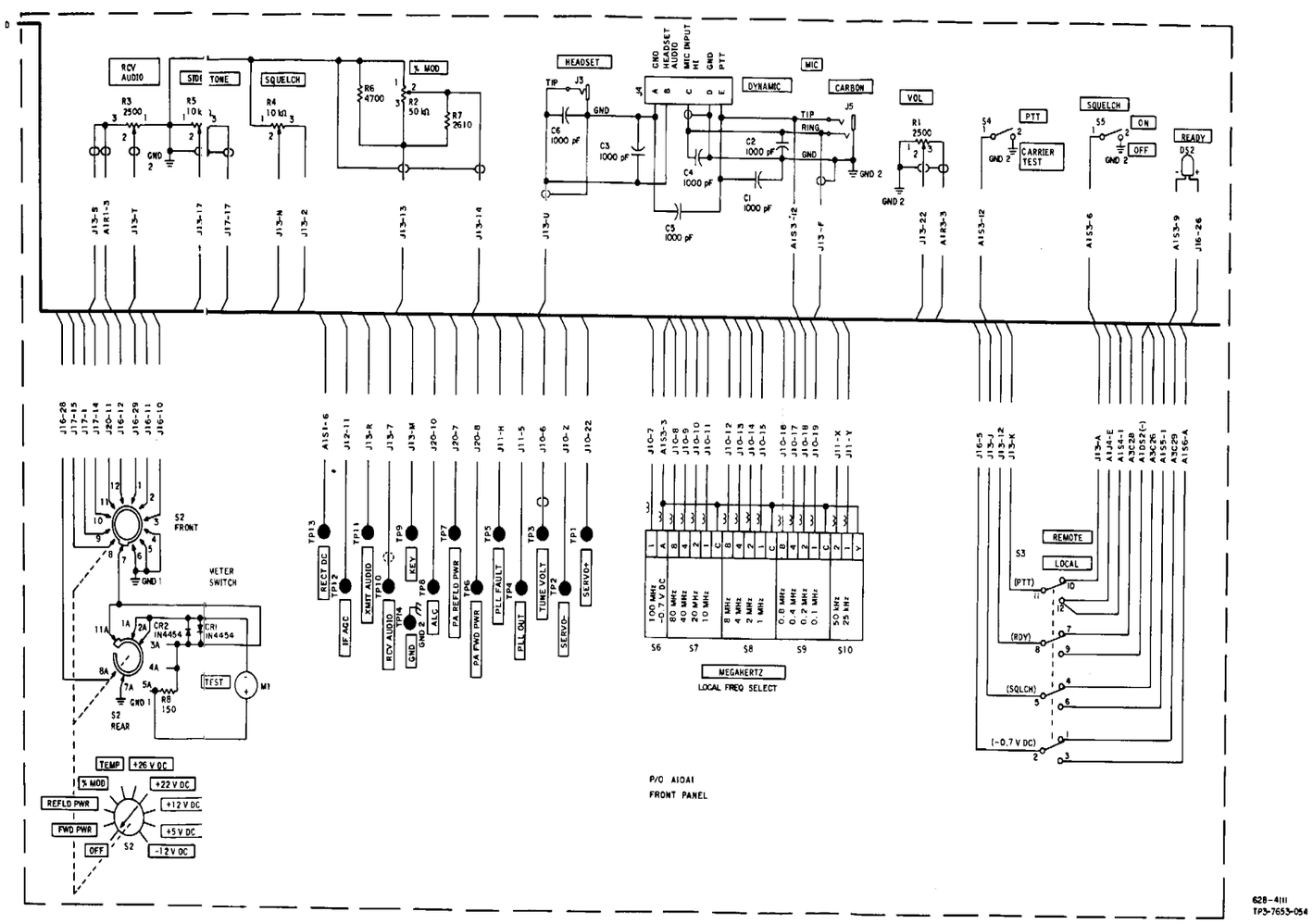
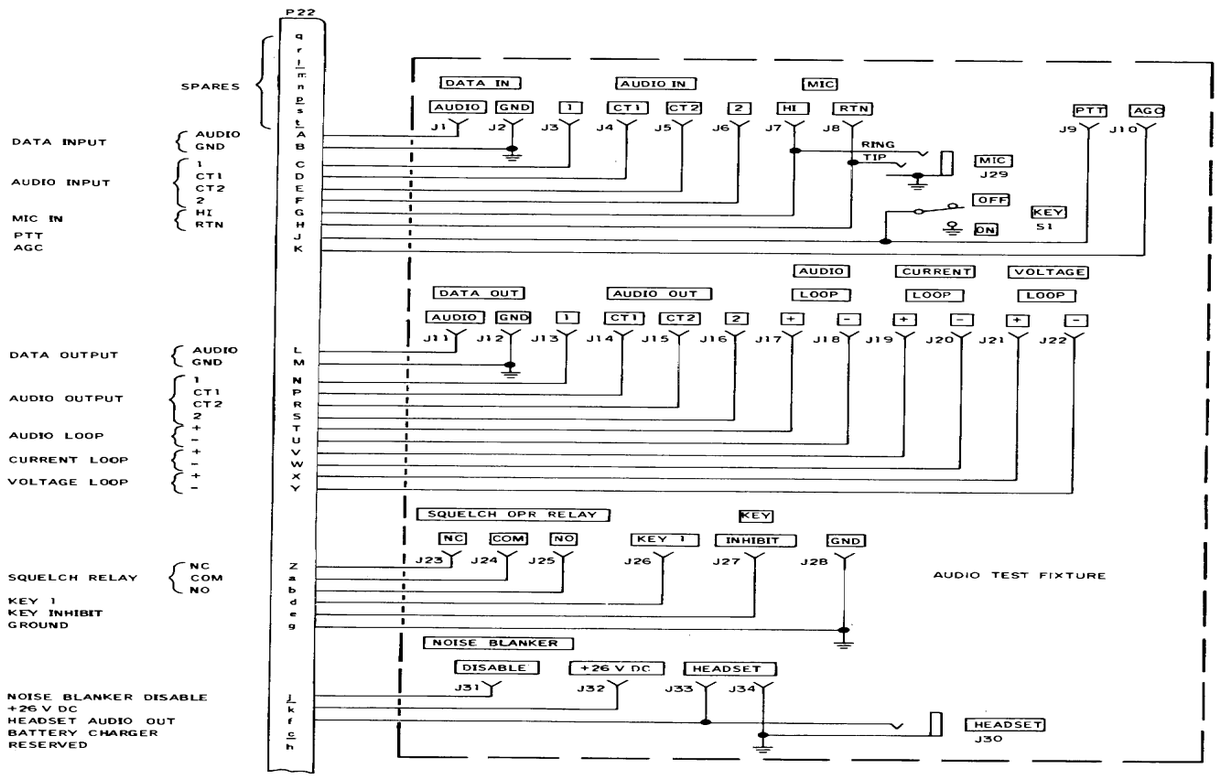


Figure FO-33. Chassis A10, Schematic Diagram (Sheet 5 of 5)



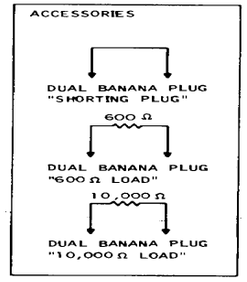
AUDIO TEST FIXTURE PARTS LIST

QTY	DESCRIPTION	PART NUMBER
1	CHASSIS, ALUMINUM 7.25 IN X 5.0 IN X 1.25 IN	LOCALLY FABRICATED
28	BANANA JACKS, RED, J1, J3 THROUGH J11, J13 THROUGH J27, J31 THROUGH J33.	SUPERIOR ELECTRIC CO. P/N DF-30BC OR EQUIVALENT
4	BANANA JACKS, BLACK, J2, J12, J28, AND J34.	SUPERIOR ELECTRIC CO. P/N DF-30RC OR EQUIVALENT
1	JACK, MICROPHONE, J29	M541-5-1 OR EQUIVALENT
1	SWITCH, TOGGLE, SPST, S1	MS75028-22 OR EQUIVALENT
1	CONNECTOR, PLUG, P22	PT08E20-41S
*AR	WIRE, HOOKUP, #22 AWG	ANY
*AR	WIRE, HOOKUP, #22 AWG, SHIELDED TWISTED PAIR	ANY
1	GROMMET, RUBBER, SIZE AS REQUIRED	ANY
*AR	SLEEVING CABLE, SIZE AS REQUIRED	ANY
1	JACK, TELEPHONE, J30	M641-6-1

*AR: AS REQUIRED

AUDIO TEST FIXTURE ACCESSORIES PARTS LIST

QTY	DESCRIPTION	PART NUMBER
6	BANANA PLUG DUAL	GENERAL RADIO 274-MB OR EQUIVALENT
2	RESISTOR, 600 OHM, 1/4 WATT, 10%	ANY
2	RESISTOR, 10,000 OHM, 1/4 WATT, 10%	ANY
AR	WIRE, HOOKUP, #22 AWG	ANY



TP4-3243-014

Figure FO-34. Audio Test Fixture, Schematic Diagram

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